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ZOOLOGICAL ATLAS

(INCLUDING COMPARATIVE ANATOMY)

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WITH PRACTICAL DIRECTIONS AND EXPLANATORY TEXT

For the Use of Students

5297

249 COLOURED FIGURES AND DIAGRAMS

BY

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INVERTEBRATA

W. & A. K. JOHNSTON
EDINBURGH AND LONDON
1881

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Dedicated

(BY PERMISSION)

TO

THE HONOURABLE LORD SHAND,

PRESIDENT OF THE WATT INSTITUTION AND SCHOOL OF ARTS,

WHOSE UNTIRING EFFORTS AND DEVOTED ZEAL IN THE CAUSE OF TECHNICAL EDUCATION

HAVE HELPED TO RAISE THE INSTITUTION TO THE HONOURABLE POSITION

IT NOW HOLDS AMONG THE TRADE SCHOOLS OF THE COUNTRY.

PREFACE

IN treating of the Invertebrata I have thought it advisable to depart slightly from the plan followed with the Vertebrata. There are five great divisions of Vertebrates recognised by naturalists, and a type or so of each was found to answer the purpose in view; but among Invertebrates the range of structure is immensely greater, and the typical forms are thereby necessarily increased. In order to preserve the just proportions of the subject, and out of the whole make a fair selection, I have treated most of the forms in less detail than the Vertebrates. Should the student desire to enter into greater detail, he will find such representative forms as the Hydra, Earthworm, Lobster, and Snail considered somewhat fully in the "Biological Atlas."

To keep the size of the work within due limits, I have generally given preference to such genera as are required for the Practical Examination of the University of London.[1] In that examination not only has the candidate to dissect specimens placed before him, but also to examine and describe *prepared* specimens, and the first four Plates of this work may be regarded as a preliminary exercise in seeing and describing. They are introduced to show how the lower forms may be studied, and how, by the use of what I have called Life-History Diagrams, the student may take in at a glance the chief features of their life.

In seeking to represent the truth of Nature by giving a mirror of the thing itself illumined by description, I am endeavouring to give books their due weight in the information and training of the student. As Carlyle said, speaking in 1840, "There is, one would say, and must ever remain while man has a tongue, a distinct province for speech as well as for writing and printing. In regard to all things this must remain; to Universities among others. But the limits of the two have nowhere yet been pointed out, ascertained, much less put in practice. The University which would completely take in that great new fact of the existence of printed books, and stand on a clear footing for the nineteenth century as the Paris one did for the thirteenth, has not yet come into existence." Shortly before this, in 1836, the University of London had come into existence, allowing one practically to get his information where and how he pleased so long as it came up to the required standard. The student, in extending his researches in a practical science like Zoology, will find that the power to interpret drawings is the secret of quick and extensive acquisition; and although each of the types here represented forms but a solitary wrought-out example of a different rule or order, they may suffice to guide him in dissecting, and train him in the study of drawings.

There are several points calling for remark, and these may be briefly disposed of under the following heads:—

[1] In the recently issued (September) syllabus of the London University there is a revised programme for Zoology. The practical work is greatly extended, and there is a list given of "skeletons and skulls for description" and "animals for dissection." As regards skeletons and skulls, the student may obtain the principal ones as indicated at the end. They are prepared and mounted by a skilled manipulator. Among the animals for dissection the student will find the following treated of in the Zoological and Biological Atlases:—

Vertebrata—Lepus, Columba, Testudo, Rana, Raia.

Invertebrata—Sepia, Limax, Helix, Patella, Anodon, Mya, Astacus, Cancer, Lepas, Oniscus, Scorpio, Julus, Scolopendra, Blatta, Lumbricus, Hirudo, Uraster.

SPECIMENS.—It is an old, but not an old-fashioned saying, "First catch your hare before you cook it," and it is necessary to have your specimen before dissecting it. It is also necessary for students to procure the object of their search as readily as possible, and to this end the most convenient places are noted. But for the sea forms I found it most convenient once for all to spend a day and night with a steam-trawl, now so common on all our coasts, and thus procure abundance and variety of material. For Edinburgh students the "Invertebrata of the Firth of Forth," by Dr. Herdman and Leslie, should prove useful.

PRACTICAL WORK.—In working over the types here given it is not desirable that the student should examine with equal fulness the smaller and the larger specimens. In many cases he should content himself with the study of the drawing, on account of the time necessary to realize it practically.

EXPLANATORY TEXT.—The brief introductory description of the animal usually gives those characters which are best observed in the living state, and which show its relations to its surroundings, while the remainder of the text describes the figures, dealing with the various parts of the animal in detail.

ACCENTUATION.—It has not been thought necessary to accentuate many scientific terms, because a general principle of easy application is coming to be recognised. For instance, such common terms as *capillary, abdomen, albumen*, etc., are now usually accented on the first syllable—capillary, ab'domen, al'bumen—notwithstanding their Latin derivation, which would lead us to place the accent on the second syllable; and this self-acting arrangement of placing the accent as near as possible to the beginning of the word is gradually extending itself to most terms both in Botany and Zoology. It is a question of classical propriety or practical convenience, and in this practical age convenience is settling it.

DEVELOPMENT, as a *rule*, is not given, not because its importance is underrated, but because it has not yet been brought within the sphere of the ordinary practical worker. Some stages of development, however, such as the Zoea and Megalopa of the Crab, may be readily procured (at the seaside or from dealers) and examined.

CLASSIFICATION.—There is no attempt made to frame a complete and connected classification, but merely a summing up of the *distinctive characters* of the forms figured and of the Orders to which they respectively belong in the order of their importance. In the very lowest forms (as in Plates I. and II.) the present state of our knowledge is summed up by arranging them in serial order, depending on the number of stages through which the organisms pass in order to complete the cycle of their life.

I am reminded by one of the most eminent living naturalists that the clearness of the illustrations might make some idle students neglect practical anatomy. To such the caution may be necessary that this Atlas is intended to serve as a guide to, and not as a substitute for, practical work, and that the whole virtue of the process consists in the *doing*.

EDINBURGH, *September* 1881.

CONTENTS.

PLATE

I. Protamœba, Protogenes, Vampyrella, and Myxastrum.

II. Protomonas, Protomyxa, Amœba, Arcella, and Difflugia.

III. Gregarinidæ and Foraminifera.

IV. Radiolaria, Catallacta, and Infusoria.

V. The Common Cross-Fish or Five-Fingers.

VI. The Sea-Urchin.

VII. The Fluke, Tapeworm, and Leech.

VIII. Cyclops, Daphnia, Balanus, Lepas, Oniscus, and Asellus.

PLATE

IX. The Crab and Spider.

X. The Scorpion, Scolopendra, and Julus.

XI. The Common Cockroach.

XII. The Common Cockroach and the American Cockroach.

XIII. Sand Mya and Scallop.

XIV. The Limpet, Whelk, and Cellar Slug.

XV. The Squid.

XVI. The Squid and Sepia.

Summary of Classification.

*** Any mistakes in the Plates are corrected in the Text.

PLATE I.

PROTAMŒBA, PROTOGENES, VAMPYRELLA, AND MYXASTRUM.

MONERA—

PROTAMŒBA (Gr. *protos*, first), found in the sea, and discovered by Haeckel.

FIG. 1. The adult form, or Myxopod (Gr. *muxa*, mucus; *pous, podos*, a foot), is a minute particle of protoplasm throwing out processes called pseudopodia (Gr. *pseudes*, false) in different directions, and drawing them in again. Minute granules scattered through its substance are constantly in motion. It moves about by means of the pseudopodia, which also drag in living particles to serve as food.

FIGS. 2 and 3. Division into two portions taking place.

DIAGRAM 1. Multiplication by simple division.

PROTOGENES PRIMORDIALIS (Gr. *genesis*, I produce), also discovered by Haeckel. Its size is about $\frac{1}{2}$ of an inch in diameter.

FIG. 4. The adult is much the same as the preceding, only the pseudopodia are long and filamentous.

FIGS. 5 and 6. Division taking place.

DIAGRAM 2. Multiplication by division as before.

VAMPYRELLA, or Little Vampire, was discovered by Cienkowski on the fresh-water spirogyra. Other species are found on diatoms and minute plants.

FIGS. 7, 8, and 9. The mode of feeding and multiplying is rather interesting. It bores its way into the plant by means of its pseudopodia, and gradually absorbs the contents. Then having satisfied itself in this way, it becomes rounded and enclosed in a case or cyst, the contents of which break up into three (or four) masses.

FIG. 10. Young form escaping from cyst.

DIAGRAM 3. Multiplication by division *after encysting*.

FIG. 11. MYXASTRUM (Gr. *muxa*, mucus; *astor*, a star) with filamentous pseudopodia.

FIG. 12. Encysted form.

FIG. 13. Division into a number of oval masses, disposed in a radiating manner from the centre, each of which becomes surrounded by a siliceous case.

FIG. 14. Siliceous cases burst, and young forms escaping.

DIAGRAM 4. Multiplication by division. The parent form encysts, dividing *into germs which also encyst*.

Order-Monera

Fig. 1.

Protamoeba.

Fig. 2.

Fig. 3.

LIFE HISTORY DIAGRAMS

I

Adult Myxopod.

Fig. 4.

Protogenes.

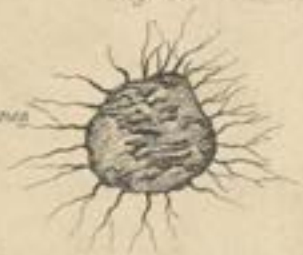

Fig. 5.

Fig. 6.

II

Adult Myxopod.

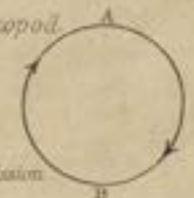

Fig. 7.

Vampyrella.

Fig. 8.

Filament of Spirogyra.

Fig. 9.

Fig. 10.

III

Adult Myxopod.

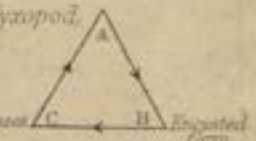

Fig. 11.

Myxastrum.

Fig. 12.

Fig. 13.

Fig. 14.

IV

Adult Myxopod.

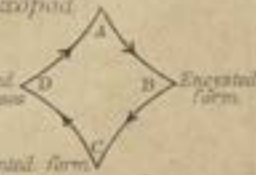

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PLATE II.

PROTOMONAS, PROTOMYXA, AMŒBA, ARCELLA, AND DIFFLUGIA.

MONERA—*continued*—

PROTOMONAS AMYLI, discovered by Cienkowski in decomposing siticlla, a fresh-water plant. Its size is about $\frac{1}{1000}$ of an inch.

FIG. 1. Adult form.

FIG. 2. Encysted form, the contents of the cyst breaking up into a number of particles.

FIGS. 3 and 4. Mastigopods (Gr. *mastix*, a whip) escaping and escaped from the cyst.

FIG. 5. Free-swimming Mastigopods become creeping Myxopods.

DIAGRAM 1. Myxopod preceded by Mastigopod.

PROTOMYXA, found in the sea, in one of its stages adhering to minute shells, such as Spirorbis, which incrust sea-weed. It is a mere speck, recognised by the naked eye from its orange colour.

FIG. 6. Amœboid form of adult.

FIG. 7. Plasmodium, consisting of a number of fused Myxopods, actively moving and feeding by means of pseudopodia.

FIG. 8. Encysted form, in which the Plasmodium has become globular and still, and surrounded by a cyst.

FIG. 9. Segmented form.

FIG. 10. Mastigopods escaping from cyst.

FIG. 11. Mastigopods passing into adult form by drawing in flagella and throwing out processes.

DIAGRAM 2. Showing an advance on Protomonas by the fusion of a number of Myxopods into an active Plasmodium before encysting.

PROTOPLASTA—

Amœba found readily in the slimy matter which collects on decaying leaves in stagnant water.

FIG. 12. Like Protamœba with a nucleus added. The space where the protoplasm diverges and comes together again is known as a contractile vesicle.

FIGS. 13 and 14. Division into two taking place, the nucleus also dividing.

FIG. 15. AMŒBA SPHÆROCOCCUS (Gr. *kokkos*, a berry).

FIGS. 16, 17, 18. Encysting before dividing.

DIAGRAMS 3 and 4. Multiplying by simple division—in some cases encysting before dividing.

FIG. 19. ARCELLA (L. a little ark), a shelled form. The test, as it is called, is of horny texture and basin-shaped. A number of nuclei are present in the protoplasm, and an air-vacuole, which serves as a float at the surface, but collapses as it sinks to the bottom of the water.

FIG. 20. DIFFLUGIA (L. *diffugium*, a refuge). The test is composed of sandy and other particles cemented together.

Order-Monera (contᵈ)

Fig. 1

Protomonas

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Protomyxa

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Order-Protoplasta

Fig. 12

Amœba.

Fig. 13

Fig. 14

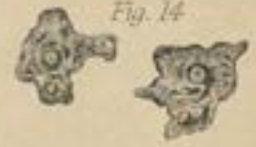

Fig. 15

Amœba sphærococcus

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Arcella.

Fig. 20

Difflugia.

LIFE HISTORY DIAGRAMS

I

Adult Myxopod.

II

Adult Myxopod.

III

Adult Myxopod.

Division into two

IV

Adult Myxopod.

Division into two — Encysted form.

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PLATE III.

GREGARINIDÆ AND FORAMINIFERA.

The Gregarinidæ are internal parasites, being found in the alimentary canal of the earthworm, lobster, cockroach, fishes, etc. Their size varies from $\frac{1}{40}$ to $\frac{1}{3}$ of an inch.

FIG. 1. Gregarina of Earthworm (*L. gregarius*, flocking together) (after Lieberkühn).

It consists of an elongated body, having neither cilia, pseudopodia, nor contractile vesicle, but possessing a nucleus. The outer layer is firm and the inner substance soft. The change of contour which it undergoes by slow contractile movements enables it to imbibe the juices in which it lives.

FIG. 2. Encysted form spherical, and nucleus broken up.

FIG. 3. Segmented form, each oval segment enclosed in a case.

FIG. 4. Pseudo-navicellæ (so called from their resemblance to navicula, one of the diatoms) set free by the bursting or dissolution of the cyst.

FIG. 5. Amœboid forms escaped, being the contents of the pseudo-navicellæ.

DIAGRAM 1. Compared with Myxastrum (Plate I.) it goes a stage further.

The Foraminifera (L. *foramen*, a hole; *fero*, I bear) are mostly marine and microscopic. Many construct beautiful skeletons, which have formed extensive deposits in the past, and are still accumulating. Thus the Chalk formation is largely composed of the shells of Globigerina (fig. 11); a later formation—the Nummulitic Limestone—chiefly composed of Nummulites (fig. 13); and the chalky ooze now forming at the bottom of the Atlantic consists for the most part of Globigerina, like those of the Chalk formation.

Shell less—

FIG. 6. Lieberkühnia naked, and reticulate pseudopodia given off from one end of the body.

Shell Imperforate—

FIG. 7. Gromia with chitinous, one-chambered shell.

FIG. 8. Miliola with porcelain like, calcareous, many-chambered shell.

FIG. 9, *a*, *b*. Lituola with arenaceous shell, coarse-grained or fine-grained.

Shell Perforated—

FIG. 10. Lagena with glassy, calcareous, one-chambered shell.

FIG. 11, *a*, *b*, *c*. Globigerina, a many-chambered shell.

FIG. 12 and DIAGRAM 1. Discorbina with chambers spirally arranged in one plane.

FIG. 13. Nummulite, coin-like, showing successive whorls of chambers. This specimen, about the size and thickness of a penny piece, was split in the median plane by a smart blow on the edge.

Order-Gregarinidae

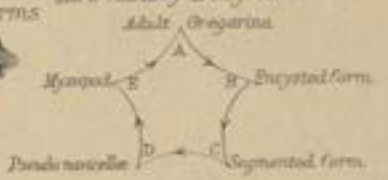
Fig 1. Gregarina. (of Earthworm.)

Fig 2. Encysted form.

Fig 3. Segmented form.

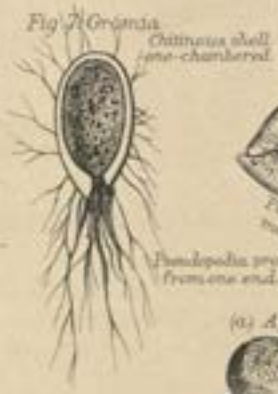
Fig 4. Free Segments or Pseudo-nauicellae

Fig 5. Amoeboid forms



Order-Foraminifera

Fig 6. Lieberkuhnia with reticulate Pseudopodia.



(a) Apex

(b) Side

(c) Base

Fig. 11 Globigerina

Fig 12. Discorbina.

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PLATE IV.

RADIOLARIA, CATALLACTA, AND INFUSORIA.

FIG. 1. ACTINOPHRYS SOL, or "Sun-Animalcule" (Gr. *aktis*, a ray; *ophrys*, an eyebrow; L. *sol*, the sun), found in ponds among the minute water plants.
The radiating pseudopodia stand out like the rays of the conventional rising sun, and the contractile vesicle is more or less prominent.

FIGS. 2 and 3. ACTINOSPHÆRIUM consists of two clearly distinguishable portions—an outer portion, or ectosarc (Gr. *ektos*, outside; *sarx*, flesh), with contractile vesicles; and an inner portion, or endosarc (Gr. *endon*, within), denser, and having a number of nuclei scattered through it. The pseudopodia possess an axial substance.

FIG. 4. HALIOMMA, with a distinct central capsule containing protoplasm, and an outer portion developing a siliceous skeleton with spines and perforations through which the pseudopodia project.

FIG. 5. ACANTHOMETRA XIPHACANTHA (Gr. *akantha*, a spine; *metra*, the womb), the body is not enclosed but supported by a siliceous skeleton consisting of spines radiating in all directions, and beset with starlike projections towards their base.

FIG. 6. SPHÆROZOUM, a compound form, consisting of—
Investing layer of protoplasm with pseudopodia.
Oval bodies protected by separate siliceous spicules and surrounded by small yellow vesicles.
Spherical bodies embedded in a gelatinous mass.

FIG. 7. MASTIGOPHÆRA (Gr. *magos*, wonderful) with nucleus and contractile vesicle and pseudopodia, broad at the base and breaking up into fine filaments.

FIG. 8. Encysted form.

FIG. 9. Segmented form freed from enveloping cyst and free-swimming. It is composed of conical bodies, their apices converging towards the centre and their bases surrounded by vibratile cilia.

FIG. 10. Single conical body with cilia, contractile vesicle, and nucleus, finally resuming the myxopod form.

DIAGRAM 1. Compare with Protomonas (Plate II.). Here the nucleated ciliated conical body replaces the Mastigopod.

FIG. 11. NOCTILUCA MILIARIS (L. *nox*, *noctis*, night; *lux*, light), about $\frac{1}{50}$ of an inch in diameter, free-swimming, and one of the causes of the phosphorescence of the sea.
Body spherical, with long flagellum, and mouth at base.
Central substance connected by numerous filaments with external layer and containing gastric vacuoles in which food is retained and used up.

FIG. 12. PERIDINIUM (Gr. *peri*, around; *dinos*, to spin) with two flagella and a circlet of cilia. Nucleus and contractile vesicle in interior.

FIG. 13. ACINETA (Gr. *akinetos*, fixed), a spherical form with tubular processes radiating stiffly, and used for sucking in nourishment.

FIG. 14. Acineta multiplying by division.

FIG. 15. PARAMŒCIUM, or Slipper Animalcule, free-swimming—
Ectosarc, or outer border—
Cuticle, or thin transparent investing layer of protoplasm.
Cilia layer with cilia perforating cuticle.
Cortical striated layer, muscular in function.
Contractile vesicles, one at each end of body, in cortical layer.
Endosarc, or internal soft substance into which funnel-shaped mouth and gullet lead—
Endoplast, or nucleus, reproductive in function.
Endoplastule, or nucleolus, outside of nucleus.

FIG. 16. Conjugation by union.
Nucleus becoming ovary with an oviduct.
Nucleolus becoming the "seminal capsule" with a seminal duct.

FIG. 17. After conjugation the "ova" become connected by the oviduct.

FIG. 18. Multiplication by division—
The body is constricting transversely and also the nucleus.

DIAGRAM 2. Showing two modes of reproduction—
1. Multiplication by division into two.
2. Conjugation in which two individuals unite, and if the nucleus be regarded as an ovary breaking up into ova, and the nucleolus as a testes developing spermatozoa which fecundate the ova, then it is a *sexual* process; but if the so-called ova independently originate Paramœcia, then it is *non-sexual*.

The forms figured in the first four Plates are all microscopic with the exception of the Nummulite. They are mostly adapted from standard works on the subject.

CLASSIFICATION—

Sub-kingdom—Protozoa (Gr. *protos*, first; *zoe*, life), the simplest forms of animals, without differentiation into cells.

Division I.—Monera (Gr. *moneres*, single), non-nucleated.

Type (in serial order)—Protamœba and Protogenes, Vampyrella, Myxastrum, Protomonas, Protomyxa.

Division II.—Endoplastica (Gr. *endon*, within; *plastikos*, fully formed), nucleated.

Order—Protoplasta, with pseudopodia, and generally contractile vesicle.

Types—Amœba, Arcella, Difflugia. (Arcella and Difflugia are often rather included in the shelled Foraminifera with lobate pseudopodia.)

Degenerate Order—Gregarinidæ, without pseudopodia or contractile vesicle, and parasitic.

Type—Gregarina.

Order—Foraminifera, usually shelled (chitinous, calcareous, or arenaceous) and with contractile vesicle.

Types—Lieberkühnia, Gromia, Miliola, Limnla, Lagena, Globigerina, Discorbina, Nummulite.

Order—Radiolaria (including Heliozoa, Gr. *helios*, the sun), usually with siliceous skeleton and body-substance differentiated into an outer non-nucleated portion and an inner nucleated portion.

Types—Actinophrys, Actinosphærium, Haliomma, Acanthometra, Sphærozoum.

Order—Infusoria, composed of an *outer layer*, usually with flagella or cilia for locomotive and prehensile purposes, and an *inner substance* with nucleus and nucleolus, virtually scooped out into an alimentary canal with two openings—a permanent *mouth* and a temporary *anus* always formed at the same place.

Types—Magosphæra (Gr. *magos*, wonderful).—Catallacta (Gr. *katallatto*, to change).
Noctiluca and Peridinium—Flagellata.
Acineta—Suctoria.
Paramœcium and Vorticella—Ciliata.

Order - Radiolaria (Figs 1-6)

Fig 1 Actinophrys sol

Fig 2 Actinosphærium

Stiff Pseudopodia

Radiating Pseudopodia

Contractile Vesicles

Fig 3 Margin of same (Enlarged)

Nuclei

Fig 4 Hallomma hystrix

Central capsule distinct

Fig 5 Acanthometra

Fig 6 Sphærozoum

Order - Catallacta

LIFE HISTORY DIAGRAMS

Fig 7 Magosphæra

Contractile Vesicle

Nucleus

Fig 8 Encysted form

Fig 9 Segmented form

Fig 10 Segment liberated

I Adult

A

Ciliated Creeping form

D

B Encysted form

C Segmented form

Order - Infusoria flagellata

Fig 11 Noctiluca

Flagellum

Filamentous protoplasm

Gastric vacuole

Fig 12 Peridinium

Nucleus

Circle of Cilia

Flagella

Infusoria suctoria

Fig 13 Acineta

Nucleus

Knobbed Tentacles

Contractile Vesicle

Fig 14 Acineta dividing

Contractile Vesicle

Infusoria ciliata

Fig 15 Paramæcium

Mouth

Contractile Vesicle

Endoplasmule

Endoplast

Contractile Vesicle

Fig 16 Two P. conjugating

Seminal capsule (Endoplasmule)

Seminal Duct

Ovary (Endoplast)

Oviduct

Contractile Vesicle

Fig 17 P. after conjugation

Endoplast

Mouth

Endoplast dividing

Opening of Oviduct

Ovary

Fig 18 P. Dividing transversely

Contractile Vesicles

Endoplasmules

Asexual II Sexual

Adult

A A

B B

Division into 2 Conjugation

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PLATE V.

THE COMMON CROSS-FISH OR FIVE-FINGERS.

THE STARFISH is exceedingly common on the sea-shore, lying apparently dead, but in sea-water setting in motion the numerous little feet on the under surface of the body, whereby it glides along the sea-bottom. The eye-spots on the tips of the five rays probably enable it to see all round, and the mouth on the ventral surface of the central disc, leading directly into the capacious stomach, which it can even protrude to envelop its prey, appropriates various molluscs as food. The great peculiarity of the Starfish, however, is the mechanism of locomotion. There are four longitudinal rows of *podials*, or little feet, in each ray, each pedical being contractile and hollow, with an expanded sucker-like ending. The hollow pedicels are filled with sea-water from a system of water-vessels called *ambulacral vessels* (see diagram 1), and by the alternate expansion and contraction of the pedicels combined with alternate holding on and letting go, the Starfish moves along bit by bit, accommodating itself to the inequalities of the surface over which it passes.

EXTERNAL CHARACTERS—

FIG. 1. A specimen may be preserved by washing well in fresh water, then drying either with or without the stomach.
Central disc with five rays.
Disc . . . { Dorsal or aboral surface with madreporite, a convex porous plate, and anus, a very small opening.
Ventral or oral surface with mouth in centre.
Rays . . . { Dorsal surface beset with spines.
Ventral surface grooved—ambulacral groove—containing the pedicels and bounded by spines.

INTERNAL ORGANIZATION—

FIG. 2. Remove with a pair of scissors the dorsal surface of central disc, leaving madreporite intact, then expose the various rays as shown. The pyloric cæca are attached to the dorsal integument and come away with it.
Stomach in centre, produced into five cardiac portions corresponding to rays.
Pyloric cavity, the dilated aboral end of stomach giving off five branches which divide in each ray.
Pyloric cæca arranged, as it were, in tufts on each side of the two divisions—only shown in one of the rays. By blowing up from the cut end of a branch the cæca may be distended.
Short intestine ending in anus.
Ovaries, two in each ray, lateral and ventral, opening by an oviduct in the angle formed by two rays.
Ambulacral vesicles or ampullæ (L. swellings).
Ambulacral ossicles arching over ambulacral groove and abutting in middle line.
Adambulacral ossicles, the stout supports of the ambulacral ossicles.

DIAGRAM 1. The water-vascular system consists of a central canal around the mouth, and giving off a *radial* canal to each of the rays.
Central canal . { Polian vesicles, cæca opening into it.
Madreporic or stone canal, communicating with exterior through madreporite, and its walls invested by calcareous matter.
Radial canals with ambulacral vesicles or dilatations of branches opening into the podicels.

FIGS. 3 and 4. Ray cut transversely near central disc and magnified—
Wall with marginal ossicles and spines.
Ambulacral and adambulacral ossicles bounding groove.
Ambulacral groove containing—
Pedicels or tube feet projecting into it.
Nerve forming a longitudinal ridge.
Neural canal separated by a transverse partition from the
Radial canal.
Internal cavity with—
Pyloric cæca in dorsal region attached to mesentery.
Ovaries, lateral and ventral.

FIG. 5. A median slit has been made along dorsal surface of ray, and a portion spread out to show entire surface of wall—
Ambulacral ossicles, a double row, with pores between each pair of ossicles for the passage of duct connecting ambulacral vesicles and podicels.
Adambulacral ossicles, a row on each side of ambulacral.
Marginal ossicles united into various patterns with connective and muscular tissues on the intervening spaces, easily seen on the dorsal surface of a dried specimen.

FIG. 6. Marginal ossicles in glycerine under the microscope—
Marginal ossicles composed of longer or shorter calcareous rods united end to end, with here and there spines attached by ligament.

FIG. 7. Pedicellaria, two-pronged, attached to spine.

FIG. 8. Nervous system may be traced from the rays towards the mouth, where it surrounds it, and towards the tip, where it ends in eye-spot.

FIG. 9. The eye is composed of an "optic pad" in which lie numerous little transparent bodies surrounded by pigment.

METAZOA (Gr. *meta*, after)—
Including all animals in which the egg, or what represents it, undergoes division, and the embryo is composed at least of two cell-layers—ectoderm and endoderm.

PLATES V. and VI.—CLASSIFICATION—
Class—Echinodermata—
Body usually with radial symmetry.
Skeleton, calcareous, in detached or continuous pieces.
Nervous system, a circum-oral ring with radiating nerve-cords.
Alimentary canal, mouth always, anus usually.
Circulatory system, closely connected with nervous system, radiating blood-vessels being known as neural canals.
Water-vascular system, generally used for locomotive purposes.
Sexes usually distinct.
Genera—Uraster, Echinus.

Diagram I Water vascular system of Starfish (in part)

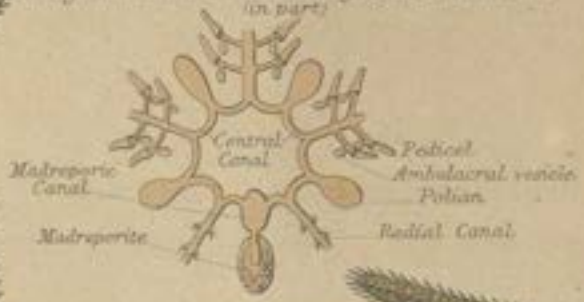

Fig 1 Dorsal Surface

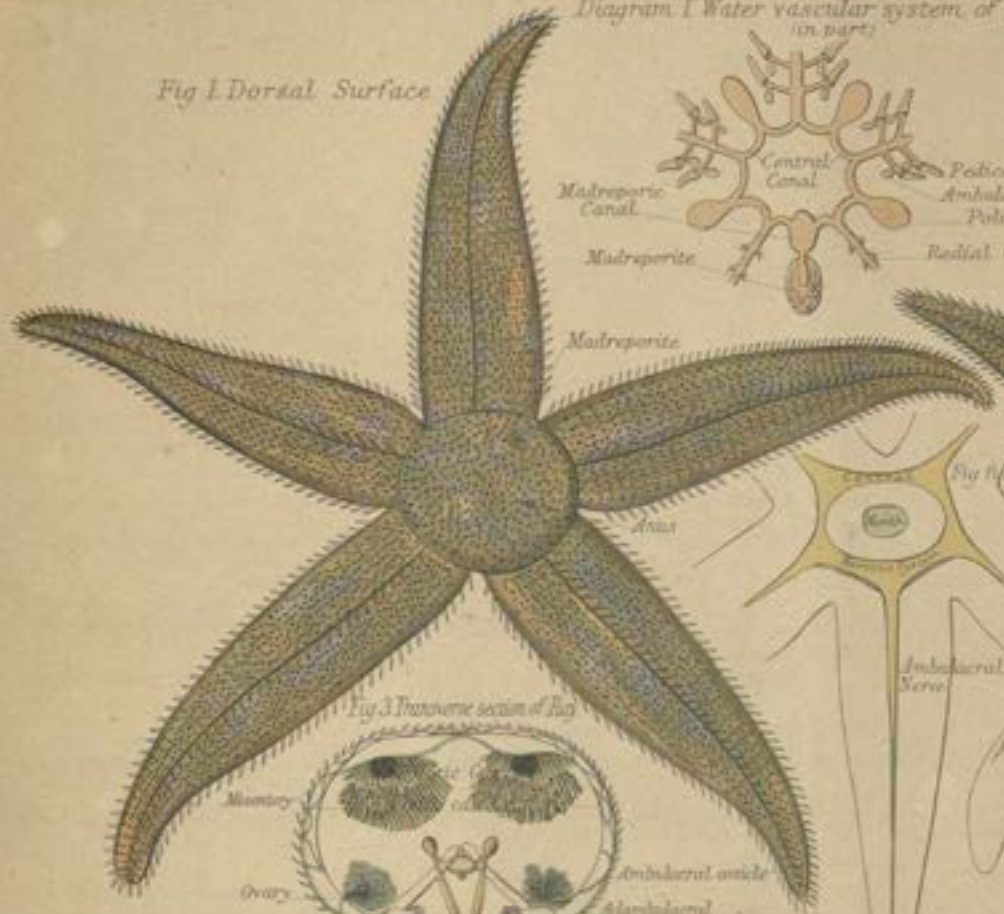

Fig 2 Dissection from dorsal surface

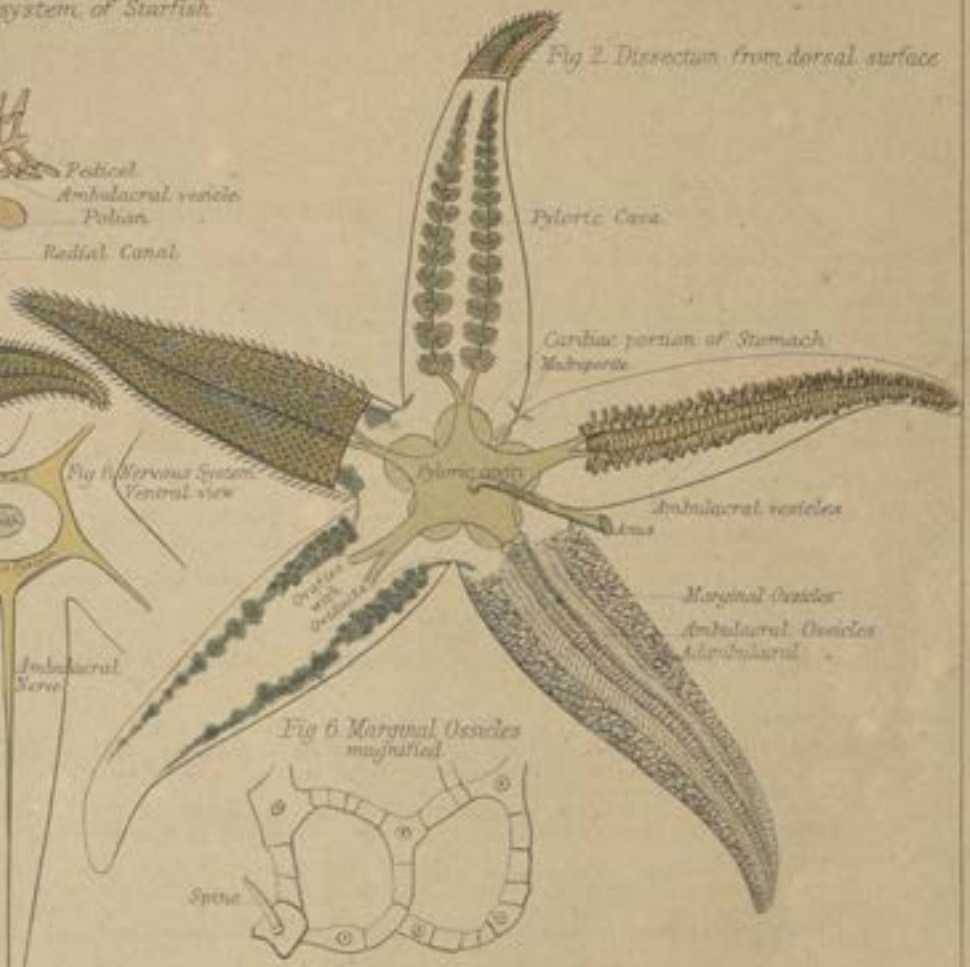

Fig 3 Transverse section of Ray

Fig 4 Ambulacral Groove enlarged

Fig 5 Portion of Ray laid open from dorsal surface

Fig 6 Marginal Ossicles magnified

Fig 7 Pedicellaria (magnified) attached to spine

Fig 9 Front view of Eye of Astropecten Highly Magnified

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PLATE VI.

THE SEA-URCHIN.

The common Sea-Urchin is to be found on the sea-shore, but there it is usually divested of its spines. Complete specimens, and of large size, are taken with the trawl-net.

Though differing widely in outward appearance from the Starfish, it has yet much in common with it, and this will be seen in detailed study. The nearly globular shell is composed of innumerable pieces all fitting exactly into one another, and the mode of growth of such a structure is exceedingly interesting. The growing integument insinuates itself between the pieces, where it becomes calcified around the edges of each piece, thus increasing its surface without altering its shape.

The shell may be beautifully cleaned for preservation by simply boiling it.

External Characters—

FIG. 1. Calcareous skeleton of closely-fitting plates, covered with movable spines acting as levers.
Ambulacral segments (five) alternating with inter-ambulacral segments (five).

FIG. 2. Ambulacral plates with pores.
Inter-ambulacral plates, larger, and with numerous tubercles for the attachment of spines.

FIG. 3. Apical or aboral pole showing—
Ocular plates (five) forming the apex of each ambulacral segment, and bearing an eye-spot.
Genital plates (five) forming the apex of each inter-ambulacral segment and having a genital pore.
Madreporite combined with genital to form one large plate.
Anus slightly eccentric, the mouth being at the opposite pole.

External Characters and Internal Organization—

FIG. 4 and DIAGRAM 1. The shell was sawn into two halves, but "Aristotle's lantern" preserved entire—

Shell—
Spines attached to tubercles.
Pedicels communicating with water-vascular system.
Pedicellariæ among the spines.
Five auriculæ (L. little ears), internal, vertical, perforated ambulacral processes.

Nervous system—
Surrounding gullet and giving off cords to each ambulacrum which pass through the perforations of the auriculæ and end in eye-spots.

Alimentary system—
Mouth surrounded by a soft area, and having in connection with it "Aristotle's lantern."
Gullet passing gradually into intestine, which is long and coiled.

Water-vascular or ambulacral system—
A circular vessel surrounding gullet giving off five radial vessels, five polian vesicles, and a madreporic canal.

FIG. 5. A horizontal section was made by sawing through the equator. In addition to showing the interior of the shell, the disposition of the intestine, the position of the ambulacral system, and the arrangement of the five united ovaries, the muscles which move the tooth-apparatus are particularly noted.

Tooth-apparatus—
Five alveoli (L. sockets), each composed of two principal pieces surmounted by an epiphysis.
Five teeth embedded in their sockets, soft at top and sharp and hard at the mouth end.
Five rotulæ, one between each pair of alveoli.
Five radii, each articulated to rotula at inner end, free and forked at outer.

Muscles—
Protractor (ten) inserted into alveoli.
Retractor (ten) inserted into alveoli.
Comminutor (ten) inserted into radii.
Interradial (five) connecting radii.

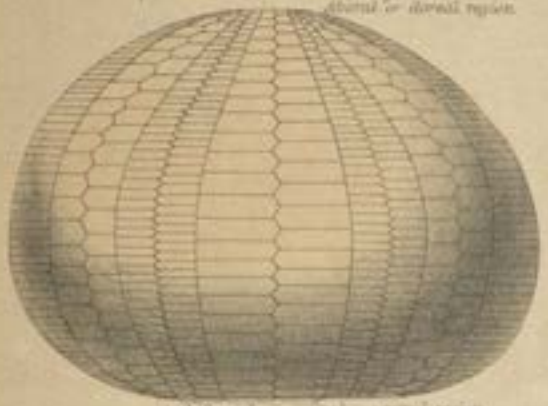
FIG. 6. The ambulacral system is clearly seen in horizontal section (fig. 5)—
Circular vessel with alternating radial vessels and polian vesicles.
Madreporic canal, membranous, extending to madreporite.

FIG. 7. Spine, pointed at free end, with socket at base for articulation with ball or tubercle on shell.

FIG. 8. Pedicel expanded into a sucker.

FIG. 9. Pedicellaria, consisting of a stalk with calcareous rod in middle and three prongs brought together by as many muscles. Their probable use is to keep the spines free from the numerous forms of life that might get entangled, settle down, and grow there.

Fig 1. Side view of Shell.
Spines detached & no markings shown. Aboral or dorsal region.



Ambulacral Segment. Oral or ventral region. Inter-ambulacral Segment.

Fig 4. Vertical Section.
(side view of "Aristotle's Lantern.")

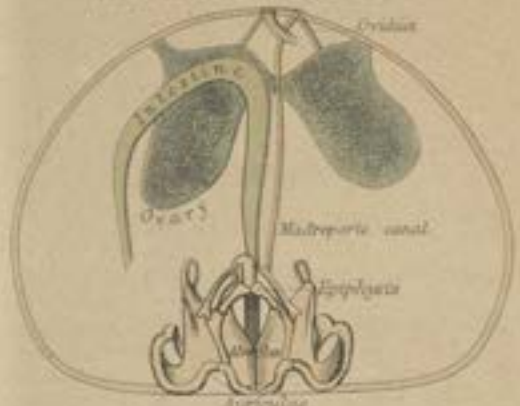


Diagram 1. Vertical Section.
showing relations of various organs.

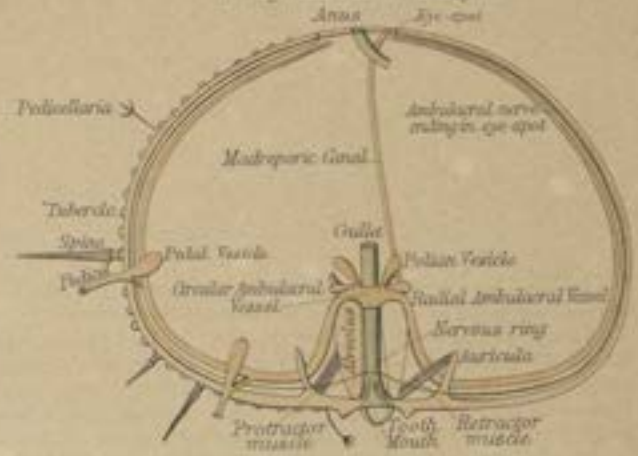


Fig 2. Markings &c. on Ambulacral & Inter-ambulacral Plates

Fig 5. Horizontal Section.

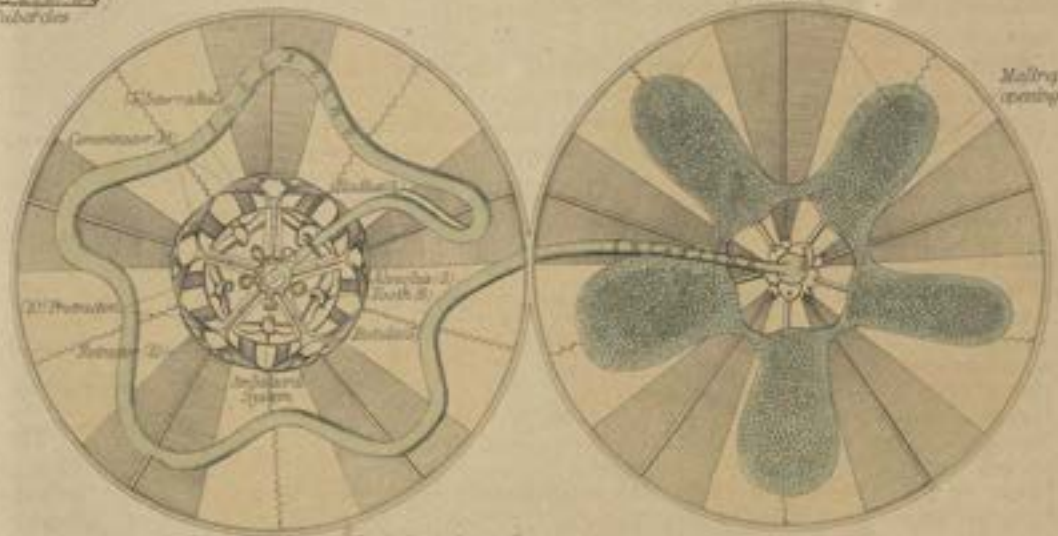


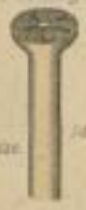
Fig 3. Apical Pole

Fig 9. Pedicellaria
(b) magnified.

Fig 7. Spine
(b) enlarged.

(a) natural size.

Fig 8. Pedicel.
(b) enlarged.



(a) natural size. (a) Natural Size.

Fig 6. Ambulacral System slightly enlarged.

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PLATE VII.

THE FLUKE, TAPEWORM, AND LEECH.

THE LIVER-FLUKE (*Distoma hepaticum*) may be readily obtained for examination from the liver of a sheep. It is of a pale-brown colour, and usually occurs in the bile-ducts. Flukes occur in various animals and in different organs; for instance, in the intestine of a dog, as well as in birds and mammals.

FIG. 1. Cut up the liver of a sheep, preferably a large one, and from the vessels of the substance of the liver, Flukes may be squeezed out.

To simply living *view* on a glass slide, the parts in fig. 1 may be made out; while for microscopic examination, either a fresh specimen or one preserved in spirit may be pressed flat between two glass slides.

Mouth at anterior end, in centre of sucker.

Ventral sucker like a mouth, hence the name Distome (Gr. *dis*, double; *stoma*, mouth).

Penis projecting on surface.

Uterus coiling shell, and usually full of ova.

Vitellarium producing shelling substance, stored up to surround yolk posterior to uterus.

Alimentary canal dividing into two branched gastric sacs.

Water-vascular system, a short, median, branched system.

DIAGRAM 1. Showing in addition to parts mentioned in fig. 1—

Muscular pharynx. Nervous system, consisting of two ganglia connected by a commissure round gullet, and giving off two cords. Ovary with dots. Testes with dots.

FIG. 2. Redia bursting in its interior, and giving rise to Cercaria.

FIG. 3. Cercaria (Gr. *kerkos*, a tail), swimming about by means of a tail. If a fresh-water snail, such as Paludina, is dissected out under the microscope, these tailed forms, not liberated as yet, may be seen.

Life-History Diagram 1. *Distoma nodulosa*, in which the different stages have been traced, exhibiting *alternation of generation*, whereby the animal passes through several stages independent of one another before completing the cycle of its life.

A. Adult, measuring in infections of water-birds, with male and female organs (hermaphrodite).

B. Ciliated embryo escaped from eggshell, free-swimming. It forms a sac in its interior (sporocyst), the cilia of the former disappear, and sets free the sporocyst.

C. Redia found in water-snail in the sporocyst, with an alimentary canal developed, and internal buds forming Cercariæ, which escape by a small opening. (The cysts of the Liver Fluke appear to inhabit the black slug.)

D. Cercaria is an active tailed form, which swims about till it finds a suitable resting-place on a water-snail.

E. Encysted form in the Cercaria with its tail dropped, and the body enclosed in a capsule.

The snail containing such cysts is generally eaten by water-birds, the capsule is dissolved in the stomach, and the escaped animal, stimulated by the nutriment and warmth inside the body, becomes the sexually mature Distome.

The common TAPEWORM (*Taenia solium*) is closely allied to Distoma, differing, however, in being segmented, each mature segment containing a complete set of reproductive organs. The head is armed with hooks, and surrounded by four suckers radially arranged, but there is no mouth, and no alimentary canal. Like other internal parasites, it nourishes itself surrounding it by the alimentary lengthening and shortening of the body.

Tapeworms can so exceed from being fed and of great length, some reaching 25 feet.

FIG. 4. Get some of the so-called "measly pork," and uncover the white specks in acetic acid or potash. The head with its hooks will then be seen under the microscope.

Rostellum (L. a little snout), bearing crown of hooklets (twenty-four).

Sucker (four).

Segments arise a little behind the head by successive budding, the mature joints readily separating, each being called a Proglottis.

FIG. 5. Tapeworms should always be placed in strong spirit, as their numerous ova might otherwise readily get into the system. Place a mature joint between two slides to see branching uterus, then it may be stained with magenta before examining under low power of microscope.

Water-vascular system on each side, united by transverse trunks.

Testes with a vesicula seminalis (L. seminal vessels) and convoluted vas deferens opening on margin.

Ovary with branched uterus (L. the womb), and vagina opening on exterior.

The uterus has usually seven branches, and is full of ova.

FIG. 6. The embryo is enclosed in a shell, which is dissolved by the gastric juice, and then the embryo escapes.

Embryo six-hooked for boring into the stomach. (In the hexad Tapeworm the embryo is ciliated.)

FIG. 7. Cysticercus (Gr. *kystis*, a bladder; *kerkos*, a tail, or Scolex (Gr. *skolex*, a worm), developed in the muscles of a pig, giving rise to the measly appearance.

Life-History Diagram, showing alternation of generations—

A. Taenia solium occurs in man, with the head and usually in the stomach, but sometimes in intestine, and consists of sexually mature segments or "proglottides."

B. Embryo, or pro-scolex, is hatched from the fertilized ovum in the stomach of a pig for instance, where the gastric juice dissolves the shell and sets the embryo free. In those cases where the mature segments are in the human stomach, the gastric juice there also will liberate the embryo.

C. Cysticercus, or encysted form, formed by the solid embryo becoming hollow, losing its hooks, and encysting. At one point in the wall a thickening takes place, which becomes the Tapeworm head.

When pork containing these cysts is eaten by man, the head of the young worm comes out from the cyst and attaches itself to the alimentary canal by its hooks. It now lengthens rapidly, the cyst drops off, and the worm becomes segmented and sexually mature.

Stages from the Egg.—1. Egg. 2. Embryo or pro-scolex. 3. Encysted form or cysticercus. 4. Scolex or head. 5. Proglottis or sexually mature segment.

The HORSE-LEECH of our ponds and the MEDICINAL LEECH of the surgery are well known. The former is the larger, but its teeth are blunter and less numerous, and its greenish-black colour is quite distinct from the olive-green of the Medicinal Leech.

They are both aquatic (although land Leeches are known), and their mode of motion and feeding may be briefly noticed.

In its native element the Leech progresses along the bottom by alternately fastening and loosening its anterior and posterior sucker, or swims in a wavy fashion.

The horse-leech is made by means of the three-toothed plates in the mouth, then it gorges itself with blood, the digestive tube with its numerous pouches enabling it to take in an enormous quantity.

EXTERNAL CHARACTERS—

FIG. 8. Kill the animal by placing it in weak acetic acid. It stretches itself out and dies in a state of extension, which is favourable for examination. Before killing, it can be made to disgorge its blood by placing it in a plate of salt, helping the process by pressing the finger along the length of the body from anus to mouth.

Body with numerous rings and longitudinal stripe of colour on dorsal surface.

Anterior sucker with mouth in centre.

Posterior sucker.

Eye-spots (ten) arranged round upper lip.

INTERNAL ORGANIZATION—

FIG. 9. Clean the alimentary canal by repeatedly passing water through it, then distend with air. Pin out in dissecting dish, and make a median longitudinal dorsal incision. This will expose the alimentary canal with its caecal dilatations.

Mouth with three chitinous toothed plates and muscular pharynx.

Gullet very short.

Stomach long, produced at the sides into eleven pouches.

Intestine slender, ending in anus.

FIG. 10. Nervous system composed of cerebral ganglia connected by commissural cords round gullet with ventral ganglia, this being the first of twenty-three.

Alimentary canal with anus opening on dorsal surface in the constriction of posterior sucker.

Segmental organs, coiled canals on each side of the body opening on ventral surface.

FIGS. 11 and 12. Chitinous toothed plate like a semicircular saw.

DIAGRAM 2. Pseudo-haemal vessels, containing a coloured fluid without corpuscles (after Gratiolet)—

Median dorsal trunk with numerous branches.

Median ventral trunk with branches to penis and segmental organs.

Lateral trunks with numerous branches.

FIG. 13. Male and female organs in same individual (hermaphrodite)—

Male Organs.—Nine pair of testicular sacs. Common vas deferens on each side. Vesicula seminalis, receiving the cases for the spermatozoa. Intromittent sac communicating with vesicula seminalis by ejaculatory duct and ending in penis, which is eversible.

Female Organs.—Two ovaries, globular bodies, each with a short oviduct opening into a common one. Vagina opening five rings behind male opening.

DIAGRAM 3. Transverse section showing the various organs in their relative positions.

CLASSIFICATION—

Order—Trematoda (Gr. *trema*, a pore)—

External or internal parasites, with flattened, unsegmented, and unciliated bodies.

Nervous system, two ganglia and two lateral nerve-cords.

Alimentary canal, bifurcating without anus.

Water-vascular system, much branched.

Hermaphrodite and alternations of generations usually.

Genus—Distoma or Fluke.

Order—Cestoidea (Gr. *kestos*, a girdle)—

Internal parasites with flattened, usually segmented, bodies and "head," with suckers and generally hooks.

Nervous system in head, rudimentary.

Alimentary canal entirely absent.

Water-vascular system present.

Hermaphrodite and alternations of generations.

Genus—Taenia solium (Gr. *taenia*, a ribbon; L. *solus*, single, because erroneously supposed to be always solitary in the human body).

Order—Hirudinea (L. *hirudo, hirudinis*, a leech)—

External parasites, with one or two suckers.

Nervous system, ganglia and ventral ganglionated nerve-cord.

Alimentary canal, with mouth having three jaws, stomach pouched, and anus dorsal.

Circulatory system, or pseudo-haemal vessels.

Segmental organs excretory.

Hermaphrodite generally, and generative openings median.

Genus—Hirudo.

Fig 1. Distoma.
Ventral view. Vertical view.

Diagram I. Structure of Trematod.

Fig 2. Redia.

Fig 3. Cercaria.

LIFE-HISTORY DIAGRAM

Fig 4. Taenia solium.
Head and enlarged.

Fig 5. Mature joint of Proglottis detached.

Fig 6. Embryo or Proscolex.
hooked. ciliated.

Fig 7. Cysticercus or Encysted form.

LIFE-HISTORY DIAGRAM

Fig 8. Extended Leech.
(Dorsal View.)

Fig 9. Alimentary Canal.
(Ventral View.)

Fig 10. Longitudinal Vertical Section.

Fig 13. Reproductive organs.

Diagram II. Principal Vessels on one side of median line.

Fig 11. Chitinous toothed plates.
b one magnified.
a Natural Appearance.

Fig 12. Calcified Teeth.
highly magnified.

Diagram III. Transverse Section.

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PLATE VIII.

CYCLOPS, DAPHNIA, BALANUS, LEPAS, ONISCUS, AND ASELLUS.

CYCLOPS is common in fresh-water ponds, where it may just be detected by the naked eye as it darts about in the water. Run a little of the water containing them into a bottle to watch their movements.

For examination under the microscope, take a glass tube drawn out to a point, and covering the other end with the finger, dip the point into the water containing Cyclops; remove the finger when the tube is immediately over the creature, and the water carries it into the tube, whence it may be transferred to a slide.

FIG. 1. Carapace with short rostrum.
Eye median and double.
Antennules long.
Antennæ short.
Thoracic appendages five pair, the last rudimentary.
One ovisac borne by first joint of abdomen. The young leave the egg in the form of a Nauplius (see fig. 8).

DAPHNIA is also common enough in fresh-water pools, where they sometimes congregate in sufficient numbers to affect the colour of the water. They avoid the surface during the hotter parts of the day, so that they are to be looked for at other times. Their transparency renders them very instructive and easily-examined specimens.

FIG. 2. Carapace covering cephalo-thorax, the thoracic portion opening like a bivalve shell.
Abdomen rudimentary.
Compound eye and simple eye.
Antennules rudimentary, on each side of rostrum.
Antennæ large and branched.
Thoracic appendages six pair.
"Shell-gland" opening on exterior.
Mouth.
Alimentary canal with a pair of cæca.
Heart in dorsal region, a short tube propelling the blood by a short anterior vessel and receiving it by two side openings.

BALANUS (Gr. *balanos*, an acorn) is to be found on every rocky coast as a conical shell, fixed to the rocks themselves or burrowing the limpets thereon. Immersed in the water, it begins to feed by sweeping about its feet in the most active manner and drawing in any floating particles of food.

When detached, the animal may be removed from its shell and the parts laid out for examination.

EXTERNAL CHARACTERS—
FIG. 3. Top view of conical calcareous shell—
Retractile appendages consisting of two pair of valves—
Terga (L. *tergum*, the back).
Scuta (L. *scutum*, a shield).
Shell composed of six pieces—
Rostrum, or anterior median piece, and rostro-lateral on each side united to form one piece.
Lateral, one on each side.
Carina (L. a keel), the posterior median piece.
Carino-lateral, one on each side.

INTERNAL ORGANISATION—
FIG. 4. Head and towards base of shell.
Thorax with six pair of appendages.
Abdomen rudimentary, giving off a penis.
Muscles of scuta and terga.
FIG. 5. Each thoracic appendage consists of a protopodite, or basal joint, and two many-jointed rami (exopodite and endopodite) provided with numerous setæ.
FIG. 6. Portion of penis, segmented, with tufts of setæ.

LEPAS (Gr. a Limpet), or Barnacle, is found attached to floating wood and various other materials, especially to ship-bottoms, where they become sufficiently numerous to interfere with the rate of speed. The fleshy peduncle for attachment is the greatly modified head, so that these creatures present the curious spectacle of a fixed head and a free posterior extremity.

EXTERNAL CHARACTERS—
DIAGRAM 1.
Peduncle long and fleshy.
Antennæ modified for attachment, and glued to foreign bodies by a cement insoluble in water.
Shell composed of five pieces—
Terga, *small* and *posterior*.
Scuta, *large* and *anterior*.
Carina, an intermediate piece.

INTERNAL ORGANISATION—
FIG. 7. Ventral view to show segmentation of body, and Diagram 1—
Mouth situated on a prominence.
Thorax with six pair of appendages.
Rudimentary abdomen with penis.
Gut-formed glands, one on each side of stomach.
Ovarian tubules in peduncle.
FIG. 8. "Nauplius," an oval body with three pair of swimming appendages and a single median eye.

FIG. 9. "Locomotive pupa" with compound eye on each side, six pair of legs, a pair of cement-glands opening at end of antennæ.
Life-History Diagram showing the principal stages in development of Balanus.

The WATER-SCATER (*Asellus*) and the WOOD-LOUSE (*Oniscus*) are closely allied forms. The first is about half an inch in length, and inhabits fresh water; the last is common in damp places, under decaying wood, etc.

The Wood-Louse is no louse at all, not even an insect, as the name might imply, but a crustacean which lives on land, and it does so without losing its essentially aquatic respiratory apparatus. The abdominal appendages perform the office of gills, and for that purpose require to be kept constantly moist. Thus the aperture breathes air dissolved in the minimum of water.

The coating of the cuticle occurs in both forms. That of the Wood-Louse may be found bleached to whiteness where it lives, and if the Water-Slater is kept in a vessel of water, there the cast-off cuticle may be found, even to the minutest detail of the accessory organs, assuming a white appearance too on drying.

EXTERNAL CHARACTERS—
FIG. 10. *Asellus*—
Head composed of seven united segments, the seventh being the anterior thoracic segment fused to the head, with appendages modified to form jaws.
Thorax of seven segments bearing ambulatory limbs, the three anterior usually directed forward.
Abdomen forming a large plate, and branchial lamellæ formed by abdominal appendages.
FIG. 11. *Oniscus*—
Head as in *Asellus*, but one pair of accessory organs rudimentary, as all air-breathing Arthropoda, only one pair of antennary organs.
Thorax of seven segments bearing ambulatory limbs.
Abdomen of six segments, with a telson.

INTERNAL ORGANISATION—
FIGS. 12 and 13. (from Gegenbaur's "Comparative Anatomy")—
FIG. 12. Alimentary canal straight, ending in anus.
Stomach with small dilatation in head having a masticatory apparatus.
Hepatic cæca long and unbranched, representing liver.
FIG. 13. Male organs composed of testicular cæca leading into a common chamber on each side from which a *vas deferens* arises to open in connection with copulatory organs.
Female organs consisting of two ovaries, each with an oviduct.

PLATES VIII., IX., X., XI., and XII.—ARTHROPODA (Gr. *arthron*, a joint; *pous*, a foot).
Body segmented.
Limbs jointed.
Nervous system forming a ring round gullet, followed by a ventral chain of ganglia.

PLATE VIII.—CLASSIFICATION—
Order—Crustacea (L. *crusta*, a shell)—
Respiration usually by gills.
Antennules and antennæ.
Head and thorax often united into cephalo-thorax.
Ambulatory limbs borne by thorax and abdomen usually.
Sub-order—Copepoda, or One-footed (Gr. *kope*, an oar; *pous*, a foot)—
Thoracic appendages, four or five pair.
Antennules long, antennæ short.
Heart and gills absent.
Embryo has Nauplius stage.
Genus—Cyclops.
Sub-order—Branchiopoda, or Gill-footed—
Thoracic appendages with gills.
Antennules small, antennæ large and branched.
Embryo may or may not have Nauplius stage.
Genus—Daphnia.
Sub-order—Cirripedia, or Ringlet-footed—
Body sessile and enclosed in enclosing shell.
Thoracic appendages, usually six pair, ending in cirri.
Heart absent.
Hermaphrodite usually.
Embryo has Nauplius stage. Retrograde metamorphosis.
Genus—Balanus and Lepas.
Sub-order—Edriophthalmata, or Sessile-eyed (Gr. *edrios*, sessile; *ophthalmos*, eye)—
Anterior thoracic segment fused to head.
Thoracic appendages, usually seven pair.
Heart elongated and many-chambered.
No metamorphosis.
Genus—Oniscus and Asellus. Gills are modified abdominal appendages, and thoracic appendages of nearly equal length.
Isopoda (Gr. *isos*, equal).

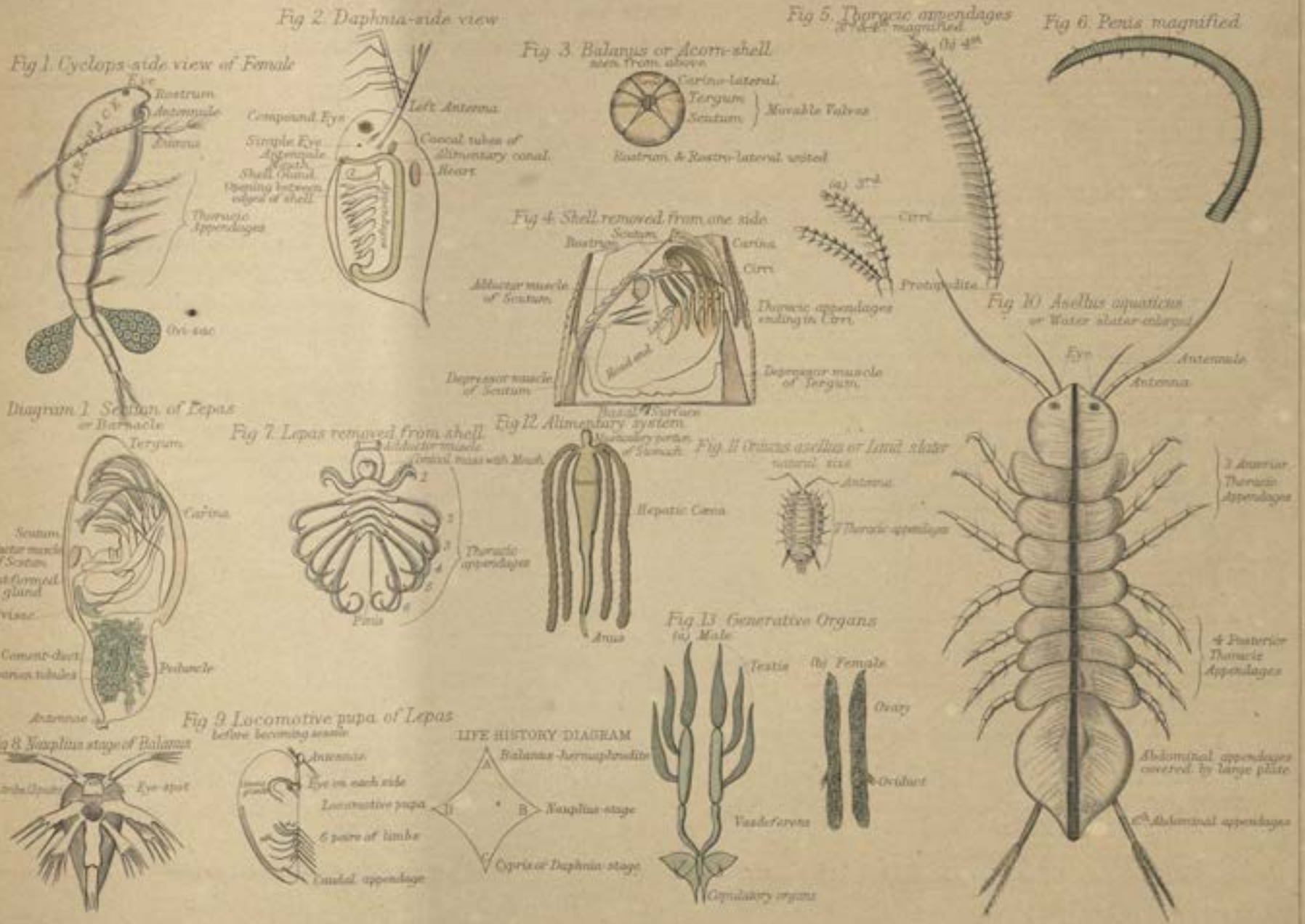

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PLATE IX.

THE CRAB AND SPIDER.

The common Shore-Crab is one of the best-known objects of the shore. Unable to swim, he frequents the shallower waters, and as the tide retreats, takes shelter beneath a mass of seaweed, or even buries himself in the sand. Its colour is of a dusky green, and the long legs enable it to move about at a rapid rate. The abdomen is usually tucked under the body, but in the breeding season the females may be found with a mass of deep red ova distending the abdomen, so that it is in line with the rest of the body. The abdomen is narrower in the male than in the female.

External Characters—

FIG. 1. Carapace with a number of markings, the cervical suture being distinguishable as a prominent depression.

Rostrum, a very slight median prolongation.

Compound eyes, set on short movable stalks, lodged in wide sockets.

Antennules short, slightly clubbed and folded upon themselves (not seen in fig.).

Antennæ, short jointed filaments.

Chelæ or pincers, more largely developed in male than in female.

Ambulatory limbs, four pair.

Abdomen rudimentary.

On ventral surface note—

In the male, the penis protruding on each side at the junction of the body-segment and base of last ambulatory limb.

In the female, the genital openings on each body-segment of the second pair of ambulatory limbs.

Internal Organization—

FIG. 2. The carapace was removed with scissors as shown while the Crab was still alive, in order to show the beating of the heart; then the stomach was distended by blowing into the mouth with a pipette.

Stomach, membranous and semi-transparent anteriorly, posteriorly strengthened by a gastric skeleton (not indicated).

Liver, a large yellowish mass on each side of stomach, and extending the whole length of cephalo-thorax. The numerous cæcal tubes arranged in tufts are clearly seen in water.

Heart, a light-coloured flabby mass.

Gills, seven on each side of cephalo-thorax, covered by a fold of skin.

Flagellum on each side, fringed with fine hairs. These flagella are long flat processes stretching across the branchial cavity and moving with the maxillipeds, to the base of which they are attached.

FIG. 3. Blood-corpuscles colourless, nucleated, and of various shapes.

FIG. 4. In fig. 4 the cerebral ganglia may be seen at anterior end of body, and the thoracic ganglia by dissecting from ventral surface.

Cerebral ganglia anterior to gullet, giving off optic nerve on each side, antennary nerves, etc.

Circum-œsophageal commissures encircling and embracing gullet.

Thoracic ganglia with small central aperture and radiating nerve-trunks to the various limbs, etc.

Abdominal ganglia represented by a cord.

FIG. 5. Cornea indicated by the black pigment shining through, and consisting of transparent cuticle divided into a number of hexagonal areas or facets.

FIG. 6. Development (from Huxley's "Invertebrata").

Zoëa (Gr. *zoe*, life) as it leaves the egg—

Carapace short with dorsal spine and projecting rostrum. Eyes sessile. Antennæ rudimentary. Abdomen without appendages.

Megalopa—Carapace long and slender. Abdomen with appendages and spread out.

The House-Spider is common enough, particularly in old houses, where their stout webs disfigure the corners. The "dusty cobweb" is evidently a trap for dust as well as flies, and the web of the Garden-Spider, with its strong threads radiating from the centre and supporting a delicate spiral thread beset with numerous sticky globules, may be conveniently examined instead. The hind legs are provided with toothed claws, and as each thread of the web is composed of several strands, it would seem that these play an important part in binding them together. The cheliceræ (fig. 8) are hooked, and as the Spider pounces upon its prey, a poisonous fluid is discharged from the point.

FIG. 7. Male smaller than female and legs longer—

Body composed of cephalo-thorax and abdomen—the abdomen is swollen and unjointed.

Simple eyes (eight) situated anteriorly on upper surface.

Cheliceræ (Gr. *chele*, a claw; *keras*, a horn) on under surface.

Pedi-palpi slender, projecting in front.

Four pair of ambulatory limbs, two pair belonging to head and the other two pair belonging to thorax.

FIG. 8. Cheliceræ, each consisting of a large basal-toothed joint, and a terminal-pointed joint folded upon it.

FIG. 9. Pedi-palpus of female like an ordinary limb, but in the male the terminal joint is adapted for receiving and conveying the spermatophores to the female.

FIG. 10. Sternum or pointed plate to which the base of the limbs are attached.

Labium or lower lip, at the sides of which are the cheliceræ.

FIG. 11. End of foot covered with numerous bristles, and having two large toothed claws and a single little claw below.

Figs. 8, 9, 10, and 11 are all equally magnified.

FIGS. 12 and 13 (from Gegenbaur's "Comparative Anatomy").

FIG. 12. Alimentary and renal organs—

Stomach with numerous cæcal processes.

Rectum much dilated.

Liver composed of tufted glands—three pair.

Urinary canals or Malpighian ducts, branched canals uniting on each side into a common duct which opens posteriorly in intestine.

FIG. 13. Circulatory and respiratory organs of a Spider—

Heart situated in abdomen, provided with three mouths, which divide it into as many chambers.

Artery distributing blood to cephalo-thorax, limbs, sense-organs, etc.

Blood returned to pulmonary sac from anterior and posterior of body by lateral passages, thus the venous system has no vessels with distinct walls.

Pulmonary sacs at anterior end of abdomen.

FIG. 14. Blood-corpuscles colourless.

Classification (Crab)—

Sub-order—Podophthalmia, or Stalk-eyed—

Eyes compound and stalked.

Gills thoracic.

Embryo has usually a Zoëa stage.

Genera—Homarus (Lobster), Astacus (Crayfish)—Macrura (Gr. *makros*, long; *oura*, tail), with long abdomen.

Cancroma—Brachyura (Gr. *brachys*, short), with small abdomen.

Fig. 1 Carcinus mœnas (dorsal view)

Fig. 2 Carapace removed.

Fig. 3 Blood corpuscles ×450

Fig. 4 Nervous system.

Fig. 5 Portion of Cornea magnified.

Fig. 6 Development.

(a) Zoea or Larva as it leaves the egg (b) Megalopa

LIFE HISTORY DIAGRAM

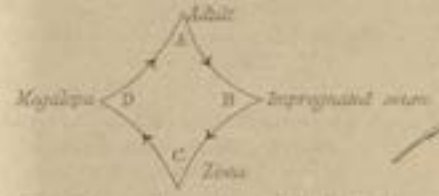

Fig. 7 House-Spider (Tegenaria domestica) (a) Male (b) Female

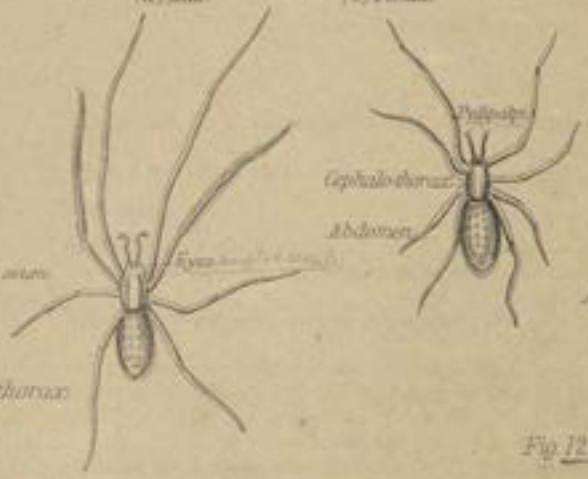

Fig. 8 Chelicera enlarged

Fig. 9 Pedi-palpus of Female enlarged

Fig. 10 Sternal portion of Cephalo-thorax & base of limbs

Fig. 11 Foot with toothed claws

Fig. 12 Digestive organs of a Spider

Fig. 13 Circulatory organs

Fig. 14 Blood corpuscles ×450

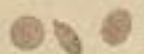

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PLATE X.

THE SCORPION, SCOLOPENDRA, AND JULUS.

THE ROCK SCORPION is a native of Africa, and about six inches long. The great claws in front and the terminal hooked segment of the abdomen are the prominent features. These are its weapons of offence.

The sting of the Scorpion is caused by the hook of the telson inflicting a wound, at the same time passing a poisonous fluid through the minute opening at the tip.

They have a formidable bearing, with their "tail" curved over their body, as they move swiftly along. They are fond of warmth and darkness, living in dark recesses, and in houses taking up their abode in all sorts of unexpected places.

EXTERNAL CHARACTERS—

FIGS. 1, 2, and 3. Cephalo-thorax, bearing on top two large sessile eyes, and round the anterior margin a series of smaller eyes—

Head
- Cheliceræ, small pincers, representing antennary organs.
- Pedi-palpi (L. *pes*, a foot; *palpus*, I touch) large and chelate, representing mandibles.
- Large labrum, or upper lip, with small mouth immediately behind, hardly admitting the point of a needle. Mouth is suctorial, to suck the blood out after wounding their prey.
- Ambulatory limbs—anterior two pair with triangular basal joints applied to mouth, and representing first and second maxillæ.

Thorax
- Ambulatory limbs—posterior two pair representing first and second maxillipedes.
- Pectines (L. *pecten*, a comb) possibly representing third maxillipedes.
- Four posterior segments with stigmata (Gr. *stigma*, an opening).

Abdomen—movable and composed of six segments, the first closely united to thorax and the last bearing a telson containing the poison-glands.

INTERNAL ORGANIZATION—

DIAGRAM I. (after Huxley)—

Nervous system—
Cerebral ganglia connected by commissures with sub-œsophageal ganglia.
Ventral nervous ganglia ted cord passing to extremity of body.

Alimentary system—
Mouth leading into a pharyngeal sac, thence into a narrow gullet expanding into a wider tube, which ends in anus on ventral surface.

Circulatory system—
Heart in dorsal region, divided into eight chambers, and distributing blood anteriorly and posteriorly.

Respiratory system—
Four pair of pulmonary sacs opening on surface by stigmata. Each sac has its walls raised into numerous plates in which the blood circulates, and there is an exchange between the carbonic acid of the blood and the oxygen of the air.

CENTIPEDES and MILLEPEDES are well known, although they are rather shunned than otherwise. They are found beneath stones in damp places and among rotting wood.

Although our native Centipedes are only an inch or two in length, in hot countries they attain a good size. The common Forked Lithobius, having a bloodshot appearance, of active habits and harmless disposition, found under stones, might be taken as a representative, but it is rather small—an inch or so in length. The Scolopendra figured is drawn from a preserved specimen. Its bite is poisonous, due to the poison-claws.

The common Garden Millepede (Julus), with its two pair of tiny feet on each segment, glides smoothly along, but if touched, coils itself up, showing no sign of life or motion.

EXTERNAL CHARACTERS—

FIG. 4. Scolopendra—Body composed of a cephalic segment or head, and a basilar segment succeeded by twenty segments.
Head with jointed antennæ and ocelli (L. little eyes) in groups on each side.
Basilar segment with poison-claws incurved beneath mouth and a pair of relatively small legs.
Twenty segments, each with a pair of legs, the terminal pair long and backwardly directed.
Genital opening at posterior end of body.

FIG. 5. Julus differs from Scolopendra principally in—Body being rounded instead of flattened and having more segments. Antennæ with fewer joints. Segments mostly with two pair of legs. Genital opening situated anteriorly.

FIG. 6. Head bearing the following—Eyes composed of ocelli. Antennæ jointed. Mandibles hard and toothed. First maxillæ soft. Second maxillæ leg-like and chelate.

FIGS. 7, 8, and 9. Mouth-parts detached in the order given—
Second maxillæ incurved and almost meeting.
First maxillæ, base united by a labium-like process.
Mandibles, each with double row of teeth and rudimentary palp.

FIG. 10. Anal and genital openings at posterior end of body.

FIG. 11. Stigmata, the openings of the trachea, on each side of the segments, immediately above attachment of leg.

FIG. 12. Leg with six joints, the last finely pointed.

INTERNAL ORGANIZATION—

FIG. 13 (from Gegenbaur's "Comparative Anatomy"). By removing the tergs of the various somites the heart is exposed. Beneath the heart is the alimentary canal. And after removal of these, the ventral nerve-cord and the tracheal system connected with the stigmata are seen.
Heart extending along body and divided into chambers corresponding to the segments.
Each chamber is held in place by alary muscles, and lateral arteries distribute the blood, which is returned by valvular lateral openings.

Anterior segments of Scolopendra=Chilopoda (Gr. *cheilos*, a lip), compared with those of Julus=Chilognatha (Gr. *gnathos*, a jaw).

Antennæ				Antennæ.
Mandibles				Mandibles.
1st maxilla	1st or cephalic segment			Maxillary plate. This plate forms a kind of under lip to mandibles, hence the name Chilognatha.
2nd maxilla			2nd segment.	2nd maxilla.
Poison-claws	2nd or basilar segment		3rd "	Pair of legs.
Pair of legs			4th "	Genital pore (♀), no appendage.
"	3rd segment		5th "	Pair of legs.
"	4th "		6th "	Two pair of legs.
"	5th "		7th "	" "
"	6th "		8th "	Male copulatory appendages and pore (♂)
"	7th "		9th "	Two pair of legs.
etc.	etc.	etc.		etc.

PLATES IX. and X.—CLASSIFICATION—

Order—Arachnida (Gr. *arachne*, a spider)—
Respiration by pulmonary sacs or trachea.
Antennary organs, one pair.
Ambulatory limbs, four pair borne by cephalo-thorax.
Abdomen without appendages.

Genera—Tegenaria, Scorpio.

Scorpionida (Scorpions) and Araneina (Spiders) contrasted.

Abdomen—	Segmented.	Unsegmented.
Respiratory organs—	Pulmonary sacs alone, four pair.	Pulmonary sacs, one or two pair, with trachea.
Cheliceræ—	Chelate.	Sub-chelate.
Pedi-palpi—	Chelate.	Limb-like.
Poison-glands—	At end of abdomen.	In terminal joint of cheliceræ.
Spinning glands—	...	At end of abdomen.

Order—Myriapoda (Gr. *murios*, ten thousand)—
Body much segmented, with distinct head and numerous feet.
Respiration by trachea.
Antennary organs, one pair.

Genera—Scolopendra (Centipede), Julus (Millepede).

Rock Scorpion (SCORPIO AFER.)

Fig 1. Tergal view

Fig 2. Sternal view

Diagram 1. General organization

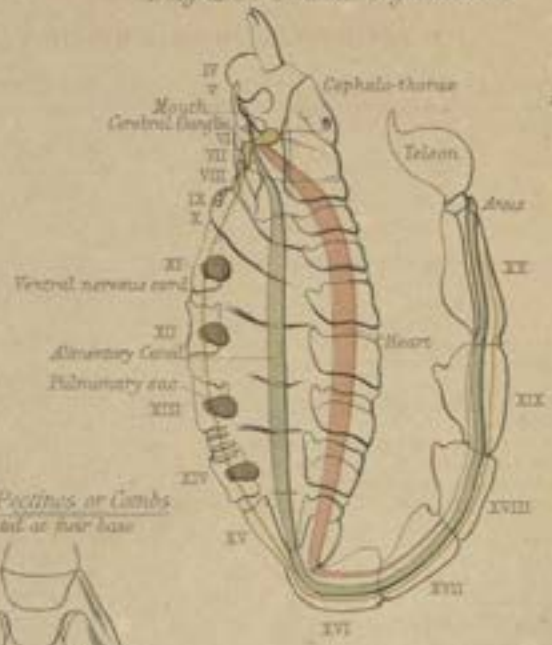

Fig 4. Scolopendra angulata
(Tergal surface-natural size)

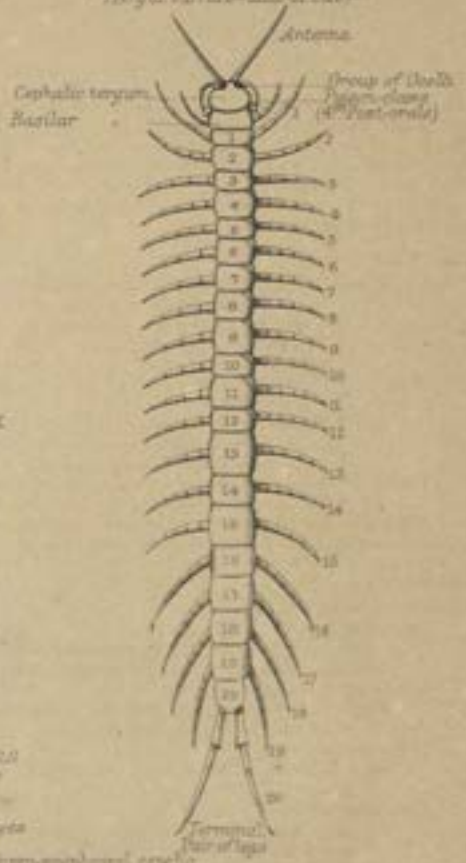

Fig 8. 1st Maxillae

Fig. 3 Pectines or Combs
joined at their base

Fig 6 Sternal view of head. end.

Fig 9 Mandibles

Fig 11 Right side view of a few successive segments

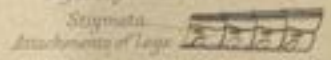

Fig 7 2nd Maxillae

Fig 10 Sternal view of last two Segments

Fig 12. Leg enlarged

Fig 13. Circulatory Organs
of head & two anterior segments

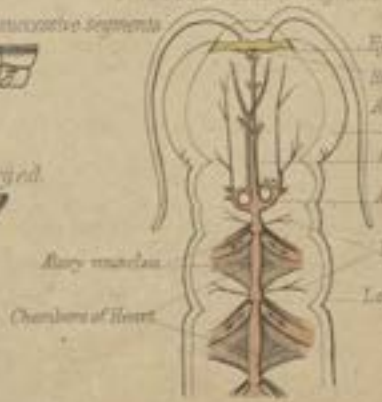

Fig 5. Millipede (JULUS TERRESTRIS)
(natural size)

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PLATE XI.

THE COMMON COCKROACH.

THE COCKROACH is well known everywhere, as it is a frequent inhabitant of our kitchens, and very common in bakeries, where there is plenty to eat. It is of a chestnut-brown colour, nocturnal in its habits, and partial to warm places. It is an active runner, and an excellent scavenger, not only devouring the common articles of diet, but digesting such tough commodities as leather, clothes, and paper. It is well supplied with the necessary tearing and crushing apparatus, having a pair of strong and toothed mandibles and a muscular gizzard, also studded with teeth. They appear to thrive on board ship, where large specimens can usually be obtained. Their disagreeable close smell, and an undefined prejudice against them, render them generally abhorred, but as one of the least modified types of insect life they are to be preferred to many of the favourite insects of the poet, the preacher, and the artist.

EXTERNAL CHARACTERS—

FIGS. 1 and 2. Actual specimen about an inch long.
- Body consisting of three regions—head, thorax, and abdomen.
- Antennæ long and slender, about length of body.
- Thorax { Pro-thorax (Gr. *pro*, before). / Meso-thorax (Gr. *meso*, middle). / Meta-thorax (Gr. *meta*, behind).
- Wings of male, two pair.
- Anterior pair, outgrowths from roof of meso-thorax, large, stiff, and horny, with numerous nervures.
- Posterior pair, membranous outgrowths from roof of meta-thorax, right slightly overlapping left.
- Abdomen in male more slender than in female.
- Cerci (Gr. *kerkos*, a tail) many jointed, minute swollen styles.
- Sub-anal styles (only in male) slender and unjointed.

FIG. 3. Compound eye on each side of head, consisting of small hexagonal facets.
- Fenestra (L. a window) on each side, small transparent spaces.
- Labrum, or upper lip, a median projection over mouth.
- Mouth-parts. (See next Plate.)
- Ambulatory limbs, three pair attached to thorax.
- Stigmata on each side of body, two pair on thorax and eight pair in abdomen.

PLATES XI. and XII.—CLASSIFICATION—

Order—Insecta (L. *in*, into; *secare*, I cut)—
- Body with distinct head, thorax, and abdomen.
- Respiration by tracheæ.
- Head with compound eyes, and one pair of antennary organs.
- Thorax bearing three pair of legs, and usually two pair of wings.
- Abdomen limbless.
- Metamorphosis common.

Genus—Blatta.

COMPARISON OF HEADS THROUGHOUT THE VARIOUS FORMS OF ARTHROPODA FIGURED.

I. CRUSTACEA (*Cirripedia*)	II. DAPHNIA (*Entomostraca*)	III. BALANUS and LIGIA (*Cirripedia*)	IV. ASELLUS & ONISCUS (*Isopoda Sessilia*)	V. CRANGON (*Podophthalmia*)	VI. TROMBIDIUM (*Arachnida*)	VII. SCORPIO (*Arachnida*)	VIII. SCOLOPENDRA (*Myriopoda*)	IX. JULUS (*Myriopoda*)	X. COCKROACH (*Insecta*)
Eyes— Median and paired.	Median, compound, and simple.	Lateral and compound in successive pairs, absent in adult.	Lateral, forming a group of simple eyes.	Compound, with movable stalks.	Eight, simple and sessile.	Two large and several small simple eyes.	Lateral, each composed of a group of ocelli.	Lateral and simple.	Lateral, simple, and compound.
Antennæ— Long and jointed.	Rudimentary.	Absent.	Well developed in Asellus, rudimentary in Oniscus.	Setæ, and slightly elongate.	Absent.	Absent.	Absent.	Absent.	Absent.
Antennæ— Short.	Long and bristled.	Rudimentary.	Long and jointed.	Relatively long and jointed.	Chelicera, sub-chelate.	Chelicerae, chelate.	Long and much jointed.	Short.	Long and jointed.
Mandibles— With rudimentary palpi.	Without palpi.	With large palpi.	Without palpi in Oniscus, with palpi in Asellus.	With palpi.	Pedi palpi, leg-like and subsidiary.	Pedi palpi, large chelate and subsidiary.	Jointed, with small palpi.	Without palpi.	Without palpi.
First Maxillæ— Strong.	Present.	Present.	Present.	Soft and foliaceous.	Represented by subsidiary limbs.	Represented by subsidiary limbs.	Soft and jointed, with median blade-like process.	Four lobed plate, with rudimentary palpi.	With palpi.
Second Maxillæ— Capable of prehension, and called "foot-jaws" or "hands."	Absent.	Present.	Present.	Do. do.	Do. do.	Do. do.	Limb-like and chelate.	Limb-like.	Labium (probably) and pair of maxillæ (sub-ad), with palpi.

Fig. 1. Male
(dorsal surface)

Fig. 2. Female
(dorsal surface)

Fig. 3. Male
(ventral surface)

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PLATE XII.

THE COMMON COCKROACH AND THE AMERICAN COCKROACH.

EXTERNAL CHARACTERS—*continued.*

FIG. 1. Mouth-parts of *B. Americana* in their natural connection, as seen under low power of microscope in glycerine—
- Labrum, or upper lip, overlapping mouth.
- Mandibles on each side, toothed, and moving inward and outward.
- First maxillæ—
  - Cardo (L. a hinge), the basal joint.
  - Stipes, the second joint, terminating in two processes—
    - Galea (L. helmet), the outer soft portion, and
    - Lacinia (L. a lobe), the inner toothed portion.
  - Maxillary palpi, each an outward knee-shaped projection from the stipes.
- Labium, or under lip (second maxillæ united)—
  - Mentum (L. the chin) with a sub-mentum behind.
  - Ligula (L. a spoon), bi-lobed. The outer terminal portion of each lobe is called paraglossa (Gr. *para*, beside; *glossa*, the tongue).
  - Labial palpi, the forward continuation of the mentum on each side.

FIG. 2. Leg consisting of—
- Coxa (L. the hip).
- Trochanter.
- Femur (L. the thigh bone).
- Tibia.
- Tarsus, composed of six joints, the terminal one having two claws.

INTERNAL ORGANIZATION—

FIG. 3. The Cockroach was embedded in paraffine and cut lengthways nearly in the middle line.
- Nervous system—See text of fig. 4.
- Alimentary system—
  - Mouth small, with salivary ducts opening into it.
  - Gullet traversing thorax and expanding into
  - Crop in abdomen.
  - Gizzard succeeded by ventriculus with pyloric cæca and Malpighian tubules.
  - Intestine ending in short but wide rectum.
- Circulatory system—
  - Heart in dorsal region of abdomen giving off aorta anteriorly to thorax and abdomen.
- Renal system—Malpighian tubes.
- Genital system—The sexes distinct.

Dissection.—A convenient way of dissecting the Cockroach and similar animals is to run a little melted paraffine into any small flat vessel, as an *in* to form a floor on hardening. Then by gently heating the paraffine and laying the animal upon it, on cooling, it sticks there and is ready for dissection under water.

FIG. 4. Remove the legs, and lay out the animal on its ventral surface as directed above, then remove dorsal integument by cutting along each side.
- Alimentary canal—
  - Salivary glands large, opening into mouth. Each gland is composed of two leaf-like lobes, with a single duct. There is also a salivary bladder on each side, and the four gland and bladder ducts unite into one before opening.
  - Gullet slender at first, then dilating into crop.
  - Ingluvies, or crop, situated in abdomen.
  - Gizzard, or proventriculus, with thick walls.
  - Ventriculus with pyloric cæca and Malpighian tubules at either end.
  - Pyloric cæca (eight).
  - Malpighian tubules, about thirty, probably serving as
  - Liver (along with pyloric cæca) and kidneys.
  - Intestine small and large, ending in anus opening posteriorly.
- Nervous system. Remove the alimentary canal, or lay it out on one side so as to display the *ventral* nervous ganglia—
  - Cerebral ganglia dorsal, giving off large optic nerves, and united by commissures to sub-œsophageal ganglia.
  - Thoracic ganglia, three, corresponding to the three divisions (fig. 3).
  - Abdominal ganglia, six.
  - Visceral nerves distributed to crop and gizzard.

FIGS. 5 and 6. By macerating gizzard the soft parts are readily removed, and the internal skeleton may thus be obtained complete—
- Section of anterior end shows lining wall with six large teeth projecting into cavity and numerous smaller teeth between.
- Section of posterior end shows circularly-arranged cushions thickly studded with setæ, and none on walls between.

FIG. 7. The beating of the heart may be conveniently observed in Cockroaches which have cast their skin. The cuticle is naturally shed, and from these white Cockroaches, as they are called, blood may be drawn for examination.

FIG. 8. Portion of trachea showing branching and spiral marking—
- The tracheæ are fine tubes with elastic walls having spiral thickenings in their interior. They ramify in all parts of the body quite as minutely as the capillaries in the higher Vertebrata. In those insects which possess great powers of flight, such as bees, some of the tubes are dilated, like air-cells in birds, so that they can be distended with air and thus render the body specifically lighter.

FIG. 9 (from Huxley's "Invertebrata")—
- Female organs—
  - Ovaries, each consisting of a series of tubes, in the interior of which the ova are developed.
  - Oviducts short, opening by a common vaginal aperture.
  - Spermatheca (Gr. *sperma*, seed; *theke*, a repository) for receiving the seminal fluid in copulation.
  - Colleterial glands (Gr. *kolla*, glue), probably secreting the case in which the eggs are carried about.
- Male organs (see fig. 5)—
  - Genital gland composed of numerous cæca.
  - Vas deferens short.

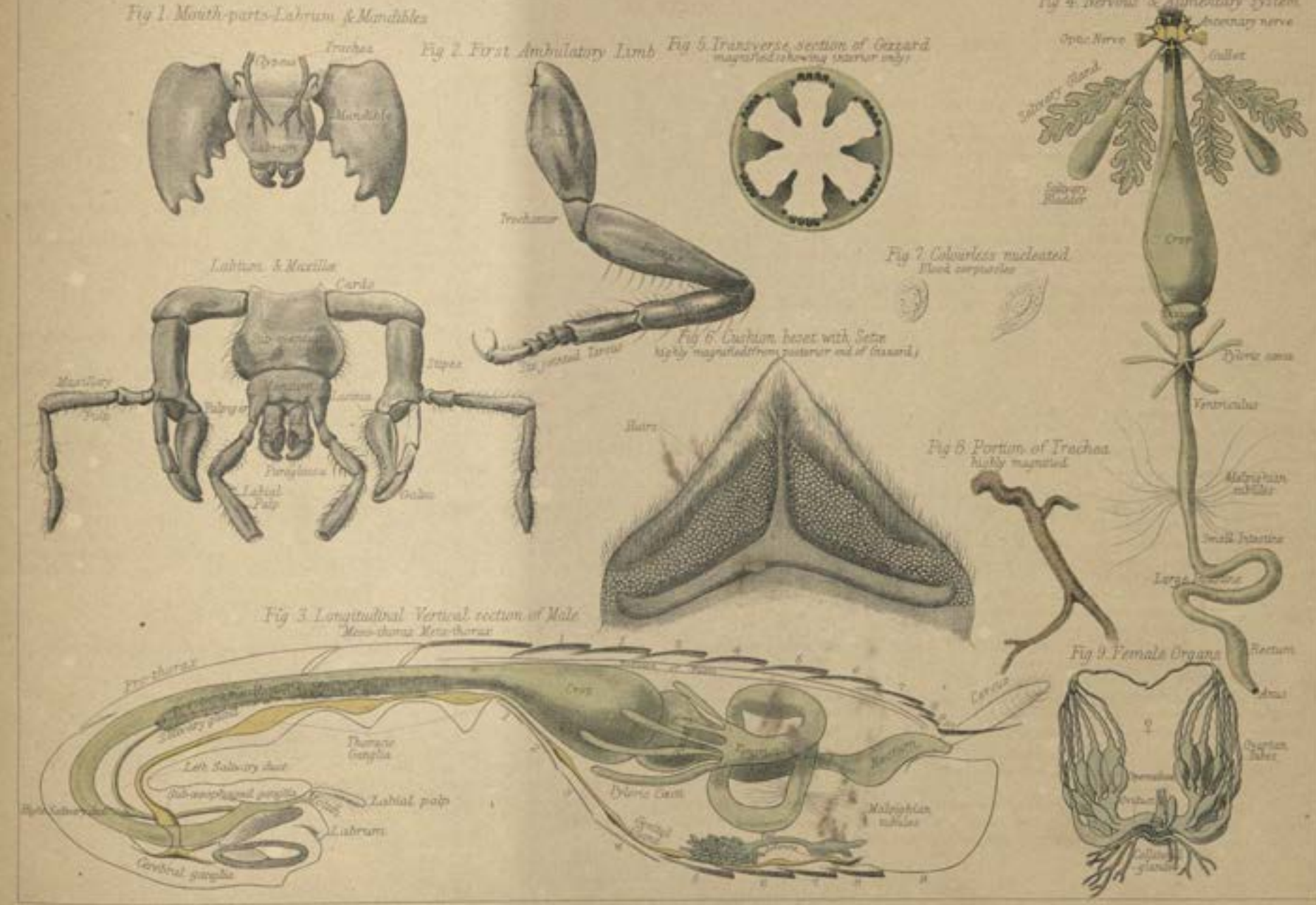

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PLATE XIII.

SAND MYA AND SCALLOP.

THE SAND MYA, as its name denotes, is to be found buried several inches in the sand, where its presence is betrayed by the small hole left by the jets of water from the siphon, and out of which the siphon is sometimes found to protrude. The shell thus lies with its posterior end uppermost.

The epidermal layer of the mantle secretes a cuticle which remains horny in the middle line where it forms the elastic ligament, but elsewhere receives a deposit of lime salts, giving rise to the hard bivalve shell. The cuticle is three-layered: the conchiolin, or outer brownish layer, is an organic substance formed by the rim of the mantle, and is continued over the siphons; the prismatic layer owes its peculiar structure to the way in which the lime salts are deposited, and is formed by the thick edge of the mantle; and the mother-of-pearl layer is formed by the rest of the surface of mantle. The thickness of the shell mainly depends on this inner layer, seeing that it alone, after once being formed, can increase in thickness.

FIG. 1. Bivalve shell—
- Anterior end rounded, posterior end more tapering, with projecting siphon.
- Umbo (L. the boss of a shield) on dorsal surface of each valve, pointing inwards and forwards.

FIG. 2. Introduce a knife at the ventral edge, and keep it close to the interior of one of the valves. Cut through the two large muscles (anterior and posterior adductors), and one valve may be removed by wrenching asunder the elastic ligament which binds the two valves together.
- Mantle, with its two lobes closely applied to the inner side of each valve, and the ventral edges united except at one place to allow egress for foot.
- Mantle edges thickened, the rest thin and membranous.
- Retractor muscle of siphons large and spreading.
- Siphons—dorsal and ventral.

FIG. 3. Labial palps, two on each side of mouth.
- Anus, opening behind and beneath posterior adductor.
- Gills, outer and inner on each side.
- Ventral or branchial siphon by which water enters branchial chamber.
- Dorsal or anal siphon by which water passes out from anal chamber.
- *Foot*, median and ventral.

FIGS. 4, 5, and 6. After hardening in spirit, the coiled intestine is dissected out in foot, and the three nervous ganglia, heart, etc.

Nervous system—
- Cerebral ganglia on each side of and behind mouth.
- Pedal ganglia in foot.
- Visceral or pareto-splanchnic ganglia below posterior adductor, giving off nerves to gills and siphons.
- Commissures uniting the various ganglia.

Alimentary system—
- Mouth leading into short gullet and spacious stomach.
- Gastric cæcum with crystalline style—a long transparent rod.
- Intestine forming four coils in foot.
- Rectum passing through ventricle of heart, over posterior adductor, and ending in anus.
- Liver well developed, surrounding stomach.

Circulatory system—
- Heart, in dorsal region, consisting of one ventricle and two auricles, enclosed as a pericardium.

Respiratory system—
- Gills, a pair on each side, each gill consisting of two leaves or lamellæ.

Renal organ—
- Nephridium, or organ of Bojanus, beneath pericardium.

Reproductive system—
- Generative cæca scattered about in substance of foot. Sexes distinct.

FIG. 7. Interior of shell—
- Tooth broad and stout, with small posterior lateral tooth.
- Anterior and posterior adductor impressions.
- Pallial impression marking the firm attachment of mantle to shell.
- Pallial sinus is the attachment of retractor muscle of siphon causing a notch in the pallial line.

The SCALLOP, or PECTEN, differs in several respects from the Mya, already considered. The shell consists of two *unequal* valves, and lies on its *side*, the more convex valve being the lower. This position enables the animal to use its eyes, which fringe the rim of the mantle-lobes, and the gape of the shell is right round too, and not only at one end.

The elastic ligament is internal, occupying a small triangular hollow, and there are no interlocking processes or teeth.

There is but *one adductor muscle* representing the posterior adductor of Mya.

Specimens are brought up with the trawl-net, as they inhabit moderately deep water.

FIG. 8. General characters—
- Ribbed shell with triangular elastic ligament.
- Mantle-lobes with eyes.
- Posterior adductor muscle very large.
- Genital organ.

FIG. 9. Alimentary canal, and nervous system in plan and elevation (see fig. 4).

FIG. 10 and DIAGRAM 1. Eyes placed on papillæ of margin of mantle—
- Cornea, a portion of epidermis without pigment.
- Sclerotic completely surrounding eye.
- Lens made up of several concentric layers of flattened cells.
- Retina, consisting of—
  - Ganglion layer of two rows of cells immediately behind optic nerve (*a*).
  - Nuclear layers.
  - Rods in front of pigment layer.
- Pigment layer, most posterior.
- Vitreous humour.
- Optic nerve double, both sending nerve-fibres from front through layers of retina to reach rods.

PLATES XIII., XIV., XV., and XVI.—MOLLUSCA (L. *mollis*, soft).

Body soft, unsegmented, and bilaterally symmetrical.
Shell generally secreted by mantle.
Nervous ganglia, three pair.

CLASSIFICATION—

Order—Lamellibranchiata (L. *lamella*, a plate; Gr. *branchia*, a gill)—
- Body without distinct head.
- Bivalve shell secreted by bilobed mantle.
- Nervous system, cerebral ganglia united by long commissures to other ganglia.
- Circulatory system, heart of two auricles and one ventricle.
- Respiratory system, gills leaf-like.
- Sexes usually distinct.

Genera—Mya, with two adductors (Dimya, Gr. *dis*, double; *mus*, muscle) and siphons (Siphonata).
- Anodon, with two adductors and without siphons (Asiphonata).
- Pecten, with one adductor (Monomya) and without siphons.

Fig 1. External appearance (right side)

Fig 2. Body right valve removed

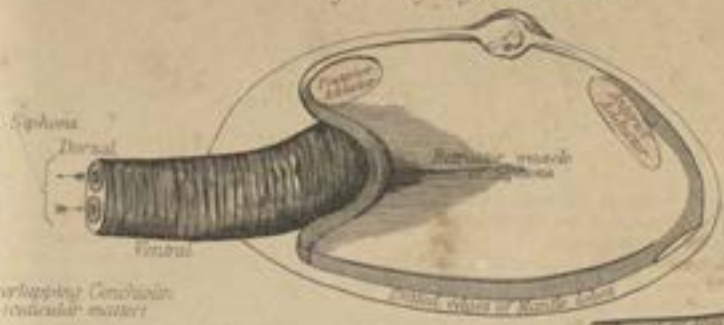

Fig 3. Right mantle lobe removed

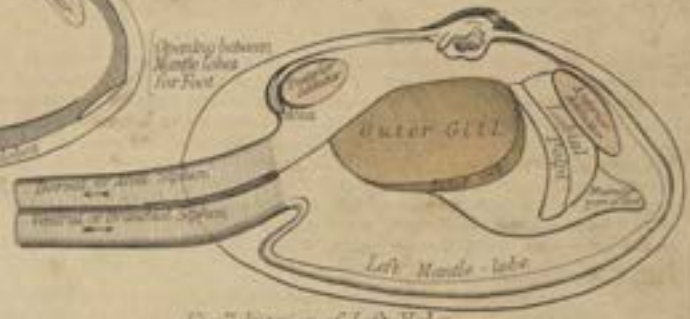

Fig 4. Dissection from Right Side

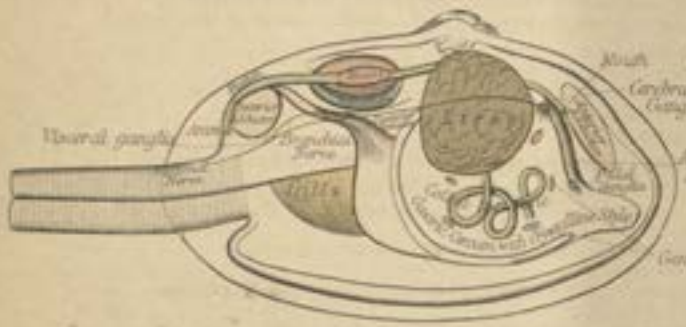

Fig 6. Alimentary Canal

Fig 7. Interior of Left Valve

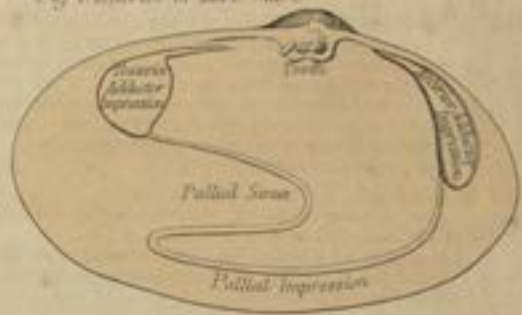

Fig 5. Dissection from Left Side Showing Nervous System in detail

Fig 8. Pecten with Right Upper valve removed

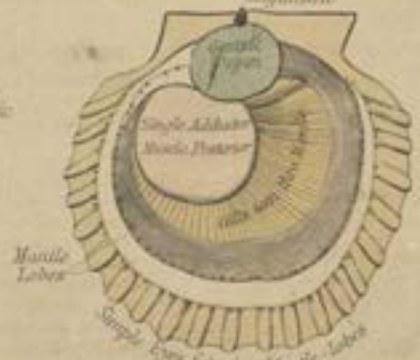

Fig 9. Alimentary Canal & Nervous System

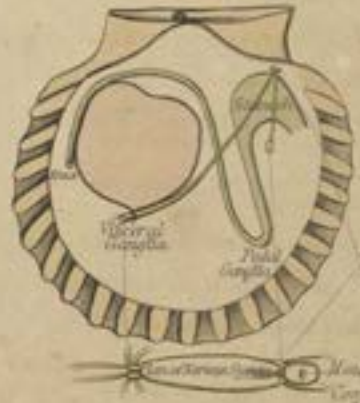

Diagram A to show Minute Structure

Fig 10. Eye of Pecten (enlarged)

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PLATE XIV.

THE LIMPET, WHELK, AND CELLAR SLUG.

THE LIMPET adhering to the rock is familiar to all. The conical form of the shell combined with its strength enables it to resist the fury of the sea, and the sucking power of the foot, which forms a vacuum by raising the centre while the rim is fixed, prevents it from being washed away. Moreover, having settled down for life on one spot, it makes a hollow in the rock, into which the rim of the shell fits, and thus intrenched it can raise the anterior end sufficiently to allow water and food to enter. The apex of the shell is directed anteriorly, in this respect differing from ordinary univalves.

To see the animal and watch its movements, it may be placed in a glass vessel with sea-water.

EXTERNAL CHARACTERS—

FIG. 1. Shell with concentric rings and ridges radiating from apex.

FIG. 2. Head bearing tentacles, and a mouth with thick lips.
Foot a flattened muscular disk for fixing the body.
Mantle firmly adherent to shell by thickened rim.
Gill-filaments circularly arranged on the inner side of the mantle.

INTERNAL ORGANIZATION—

FIG. 3. The animal has been removed from shell, to expose the visceral sac projecting on dorsal surface. The mantle has been partially removed.
Circular muscle.
Intestine in various coils with anus opening towards right side of body.
Liver, a brownish mass filling a large part of the visceral sac.
Heart consisting of auricle and ventricle.
Nephridia (left one atrophied) opening on each side of anus.

DIAGRAM 1. Eye on the swollen base of each tentacle—
Sclerotic consisting of the dermis and surrounding nerve.
Lens transparent.
Retina—
Rods.
Cell-layer.
Pigment-layer at base of rods.
Optic nerve forming optic cup.

FIG. 4. Radula long and coiled. Spread out portion under highest power of microscope to see transverse rows of teeth.

FIG. 5 (after Cuvier)—
Mouth leading into gullet, which passes through dorsal part of buccal mass.
Buccal mass, from which radula passes ventrally and posteriorly.
Stomach, a slight dilatation.
Intestine much coiled, opening anteriorly in anus.

The common WHELK is briefly noticed as a convenient representative with spiral univalve shell, plume-like gills, protrusible foot, and an operculum.

EXTERNAL CHARACTERS—

FIG. 6. Shell univalve and spiral, consisting of a body-whorl, with notch in margin, and other smaller whorls, the spire.
Foot by means of which the Whelk creeps.
Head with retractile proboscis, and pair of tentacles with eyes at base.
Respiratory siphon, a portion of the mantle for conveying water to branchial cavity.

INTERNAL ORGANIZATION—

FIG. 7 (after Huxley)—
Mantle investing body.
Foot with horny operculum (L. a lid) on posterior part.
Nervous system—Three sets of ganglia collected round gullet.
Alimentary system—
Mouth at end of proboscis with salivary glands opening into it.
Odontophore (commonly given in text-books).
Gullet long, leading to crop, thence to stomach.
Intestine ending in anus.
Circulatory system—Heart situated posterior to gills, which are not shown.
Renal system—Renal aperture on right side of body.
Reproductive system—Oviduct shown.

The CELLAR SLUG is found in cellars and damp dark places, where it roams about at night to pick up any refuse that may be about. *Limax maximus*, or the large grey Slug, likewise occurs there, but *L. flavus* is known by its yellowish body, variegated with dark spots.

EXTERNAL CHARACTERS—

In order to have the animal fully extended for examination, put it into a solution of corrosive sublimate as it crawls about, and its death will shortly take place without any contraction.

FIG. 8. Body four or five inches long.
Foot forming the flattened ventral portion.
Head bearing a pair of tentacles with eyes, and a pair of tentacles without.
Pallial region or shield, forming a sort of saddle.
Internal shell removed from that part of pallial region above which it is placed.
Anus and respiratory opening near posterior boundary of mantle.
Genital opening near base of tentacle.

INTERNAL ORGANIZATION—

FIG. 9. Showing muscles of buccal mass and of tentacles.

FIG. 10. Nervous system—Cerebral ganglia round gullet.
Alimentary system—
Buccal cavity, gullet, stomach, intestine, anus.
Salivary glands opening into buccal cavity.
Liver in two lobes.
Circulatory system—Heart, consisting of auricle and ventricle.
Respiratory system—(Pulmonary chamber, in the walls of which blood-vessels ramify.
Renal system—Nephridium, situated naturally to right of heart.
Reproductive system—Anterior end shown.
Semper's organ of unknown function on each side of buccal mass.

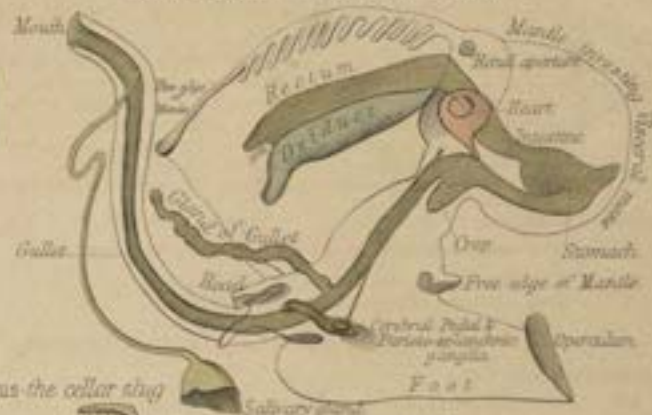
FIG. 11. Nervous system, consisting of cerebral, pedal, and parieto-splanchnic ganglia, and a stomato-gastric ganglion on each side, giving off nerves to mouth and gullet.

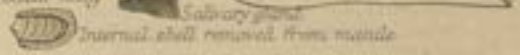
FIG. 12. Generative organs—
Ovo-testis or hermaphrodite gland with duct.
Albumen gland, so called because it forms an albuminous secretion.
Vas deferens, for conveying spermatozoa and opening into penis.
Oviduct for conveying ova, ending in vagina.
Spermatheca or receptacle of the semen, opening into vagina.
Genital opening (see fig. 8).

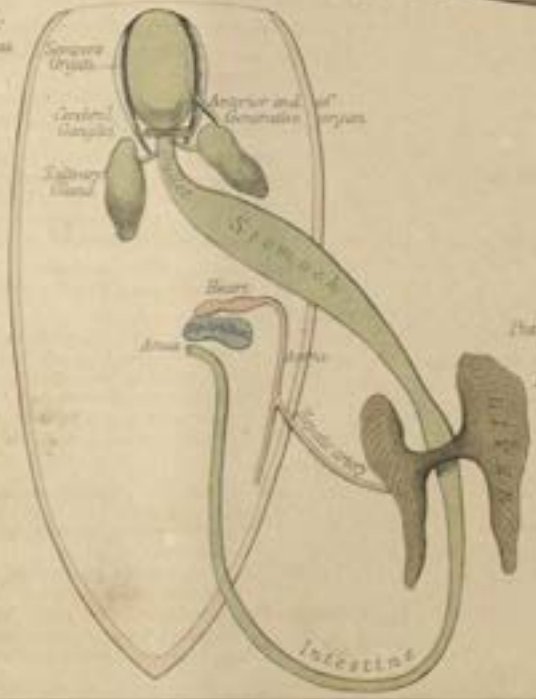
CLASSIFICATION—

Order—Gasteropoda (Gr. *gaster*, the belly)—
Body with distinct head, and foot flattened out ventrally.
Univalve shell secreted by mantle, which is never bivalved.
Odontophore.
Nervous system, usually collected round gullet.
Circulatory system, heart usually of one auricle and one ventricle.

Genera—Patella and Buccinum, with gills and auricle in front of ventricle. Prosbranchiata (Gr. *pro*, in front), sexes usually distinct.
Limax, breathing air direct by means of pulmonary chamber. Pulmonata, hermaphrodite.







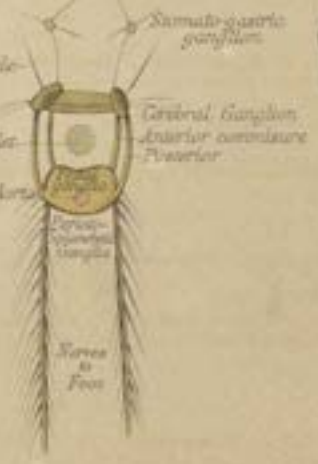


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PLATE XV.

THE SQUID.

The common Squid, or Inkfish of the fishermen, belongs to the same group as the Cuttlefish, the Octopus, and the Nautilus. It is common enough in the autumn, when scores of them are taken in the trawl-nets, but they rarely survive the operation of dragging in. They are sometimes met with on the shore in pools left by the retreating tide, where their habits and movements may be noted.

At first sight no two forms seem more unlike than the Mussel buried in the sand and the Squid darting through the water, and yet they are ranked together among the Molluscs. Wherein the difference mainly lies will be seen from the following brief description.

The body is covered with a soft mantle, and the head possesses two large eyes and is surmounted by a crown of processes or feet, from which the name of the order, Cephalopoda, or "head-footed," is derived. Between the free fold of the mantle and the body there is a cavity into which the branchial plumes project, and leading from this cavity, a swollen tube opening by a narrow mouth. This funnel, as it is called, plays a very important part in the economy of the animal.

The Squid not only moves along the bottom head downwards, but swims with great rapidity, aided and directed by the lateral fins alongside the mantle. Its most active mode of swimming, however, is backwards, which it accomplishes by squirting a jet of water through the funnel, the reaction of the water propelling the animal in an opposite direction, and the water thus expelled has bathed the gills and served respiratory purposes. The gills are not provided with cilia, as in other Molluscs, to set the water in motion, but they are muscular and consequently contractile.

The mouth is provided with a beak, black, horny, and sharp, like that of a bird. This evidently serves to crush the animal food on which it preys.

The ink-bag is another peculiar structure, so called from its containing an inky fluid, composed largely of carbon and an exceedingly powerful pigment. This fluid is employed as a means of defence or escape from its enemies, for when irritated it discharges a quantity of the fluid and retreats under cover of the blackness.

The organs of adhesion, or suckers, are arranged upon the ten processes of the head. These processes are variously named according to their use—"arms" in the present instance when they serve, "feet" when they serve for movement; and the two longer ones are sometimes called "tentacles," because they are of the nature of feelers. The small sucking disks are muscular cups with thick walls, in the bottom of which is a retractile prominence, the whole apparatus acting like a boy's sucker. The sucking disk is squeezed against any surface, and the attractor muscles pull the central plug back, so that a vacuum is created and the pressure of the atmosphere is now only on one side, exerting a force of about fifteen pounds on the square inch. There is a horny toothed rim round the cup which gives mechanical adhesion, and the numerous suckers all acting together give the animal a very powerful hold of any object, while the plug has simply to be put forth again in order to let go.

The shell is internal, forming a thin horny, transparent, pen-like structure in the Squid, and a stout calcified "cuttle-bone" in the Sepia. The cuttle-bone is excessively light and fragile, and may be reduced to a fine powder which is very absorptive, hence it was used in bygone days as "pounce" for drying ink, before blotting-paper was made. Although so thick, it is sufficiently light to float on water, because its numerous interspaces are filled with air, so that it must give relative lightness to the region of the Sepia in which it is placed.

Finally, the change of hue to which it is liable may be noted. To see this, watch one as it moves about in some rocky pool, and on gentle irritation it will display those varied hues, ranging from a warm and fleshy tint to a pale and neutral one.

External Characters—

FIG. 1. Animal in walking position—dorsal or pointed end uppermost, ventral or oral end downwards, posterior or anal surface, and anterior surface lodging pen—
- Mantle enveloping body like a sac.
- Chromatophores (Gr. *chroma*, colour; *phoros*, I bear), colour-sacs in the integument, which, by their expansion or contraction, change the shade of colour.
- Arms encircling head.
- Acetabula (L. *acetabulum*, a cup), cup-like suckers.
- Eyes large and prominent on each side of head.
- Infundibulum (L. a funnel) opening on posterior surface of body.
- Fin, triangular, on each side of mantle.

FIG. 2. Mouth provided with beak and surrounded by fringed lip.
- Buccal membrane prolonged into lobes.

Internal Organization—

FIG. 3. The soft mantle may be readily slit up with scissors, the posterior surface being chosen, as it is opposite to pen. Tie the mouth of the ink-bag and be careful not to cut it.
- Cerebral and stellate ganglia only shown. Each stellate ganglion should have been placed towards the attached end instead of the free end of the gill, as in fig. 4.
- Intestine passing straight from stomach to anus in the middle line of body.
- Branchial hearts, one for each gill.
- Gills, one on each side, plume-like.
- Ovary only prominent during breeding season.
- Oviducal gland supported by muscular bands, with subsidiary glands in its course, and opening near to anus.
- Ink-bag opening close to anus.

FIG. 4. Nervous and alimentary systems laid out—
- Towards the attached end of each gill the stellate ganglion is readily seen, whence the nerves to mantle and towards head may be traced.
- The intestine is turned over from the middle line.
- Nervous system—
  - Cerebral, pedal, and parieto-splanchnic ganglia concentrated about gullet.
  - Buccal ganglia in connection with buccal mass.
  - Stellate ganglion on each side.
- Alimentary system—
  - Gullet, long and slender, upon which salivary glands are developed.
  - Stomach roundish.
  - Pyloric cæcum long and pointed, arising from gullet and of stomach.
  - Intestine in natural position is straight and not looped.
  - Liver largely developed.
  - Pancreatic glands composed of glandular follicles.

FIG. 5. By slitting up the membrane and lip, the two parts of the parrot-like beak may be easily removed separately and preserved dry.

FIG. 6. The horny toothed ring removed from one of the suckers.

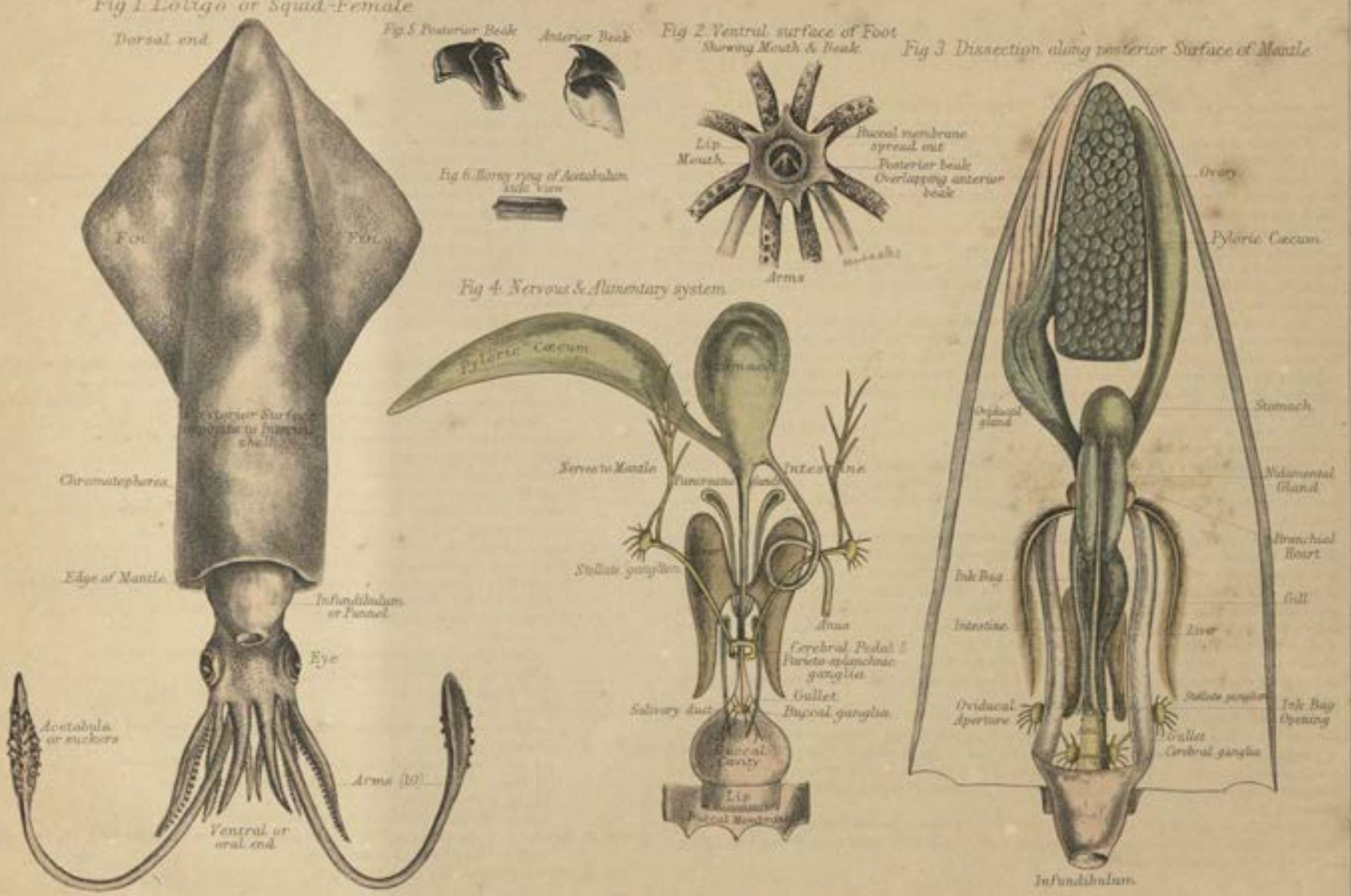

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PLATE XVI.

THE SQUID AND SEPIA.

INTERNAL ORGANISATION OF SQUID—*continued*.

FIG. 1. Pen lodged in mantle in a sort of pouch, from which it is easily withdrawn by laying hold of the slightly projecting stalk. Underlying pen shows the transparency of the object.

FIG. 2. After removal of beak, the buccal mass may be easily detached—
Taste-organ, soft and spongy.
Odontophore, the radular portion of which is seen.

FIG. 3. Buccal cavity exposed and odontophore removed—
Odontophore—
Skeleton consisting of two thin sheets of cartilage.
Sub-radular membrane with its muscles.
Radula, or toothed plate, forming the surface of sub-radular membrane.

FIG. 4. Radula spread out shows numerous transverse rows of teeth, each row consisting of a median tooth with three on each side, and lateral marginal plates.

FIG. 5 (from Brunn's "Thier reich"). Male organs consisting of testis and excretory duct, the parts of which are bound up together and require to be unrolled.
Testis occupying similar position to ovary in female.
Excretory duct—
Vas deferens, a coiled tube dilating into vesicula seminalis (L. seminal vesicle).
Prostatic gland secreting the cases or spermatophores containing spermatozoa.
Spermatic sac, or receptacle of spermatophores, opening on a papilla in the mantle cavity, the so-called penis.

INTERNAL ORGANISATION OF SEPIA, to contrast with that of Loligo—

FIG. 6. Lip and beak shown in their natural relations.

FIG. 7. "Cuttle-bone," same position as in Squid.

FIG. 8. Compare with fig. 6, Plate XV.
The intestine has a slight loop and is not quite straight.

DIAGRAM 1 (from Gegenbaur's "Comparative Anatomy")—
Cephalic cartilages.
Optic nerve enlarging into ganglion, then expanding to form cup.
White glandular body on each side of ganglionic enlargement.
Sclerotic, cartilaginous, penetrated by the nerve-fibres.
Cornea, transparent epidermis with a small opening.
Iris with its cartilage, projecting into anterior chamber, which contains sea-water.
Tapetum silvery, ending in iris.
Ciliary body fibro-muscular, extending from sclerotic and fitting into lens.
Lens oval in the direction of the optic axis.
Vitreous humour clear and transparent.
Retina lining the cup—
Layer next to cup containing nerve-fibres and ganglionic corpuscles.
Layer next to vitreous humour containing the rods, which are thus turned *towards* the light.
Pigment layer between.

FIG. 9. Heart muscular, propelling blood anteriorly and posteriorly.
Auricle on each side, returning blood to heart from gills.
Vena cava, distributing blood to each nephridium or organ of Bojanus.
Branchial heart on each side, a dilated portion of vena cava after passing through nephridium on its way to gills.

FIG. 10. Male organs as in Squid.

FIG. 11. Female organs, consisting of ovary, oviduct, and glands—
Ovary with oviduct, and oviducal glands near opening.
Nidamental glands and accessory glands secreting material for coating and binding together the ova.
In Sepia each egg has its own capsule, but in Loligo a number (thirty or more) are enclosed in one long tubular capsule.

PLATES XV. and XVI.—CLASSIFICATION—

Order—Cephalopoda (Gr. *kephalē*, the head)—
Body with distinct head and large eyes.
Foot extending over head, and margin produced into a circle of arms or tentacles.
Funnel, the united epipodia.
Odontophore.
Sexes distinct.

Sub-order—Dibranchiata—
Arms, eight or ten, provided with suckers.
Funnel, a complete tube.
Ink-bag.
Gills, auricles, and renal organs—a pair of each.

Genera—Loligo and Sepia—Shell internal, and ten arms (eight short and two long). Decapoda (Gr. *deka*, ten)

Fig 1 Internal shell or Pen. natural size

Fig 2 Buccal mass detached

Fig 3 Radula & cartilages removed natural size

Fig 4 Transverse rows of Teeth of Radula highly magnified

Fig 5 Male organs

Fig 6 Lip & Beak of Sepia side view

Fig 7 Septostaire or Cuttle bone natural size

Fig 8 Alimentary & Nervous systems

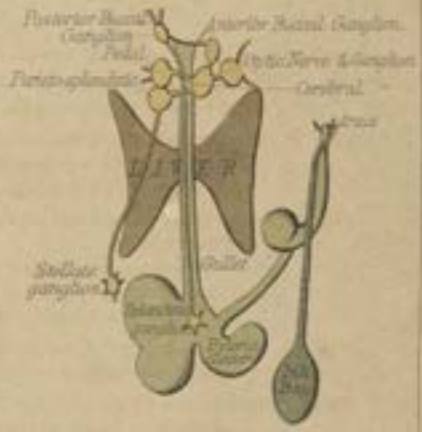

Diagram 1 Horizontal section of Eye

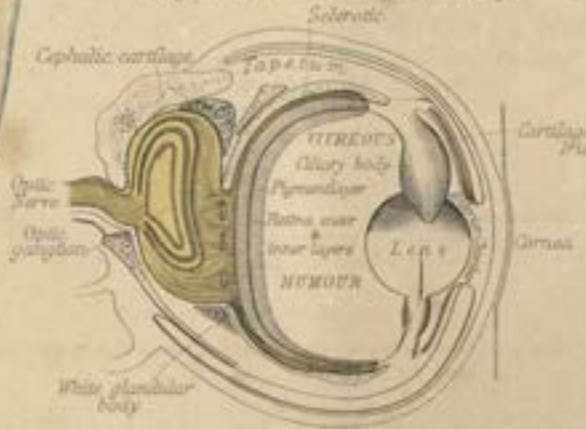

Fig 9 Circulatory Respiratory & Renal organs

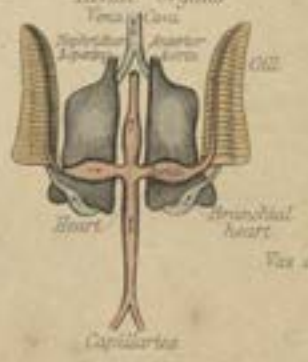

Fig 10 Male Organs

Fig 11 Female Organs

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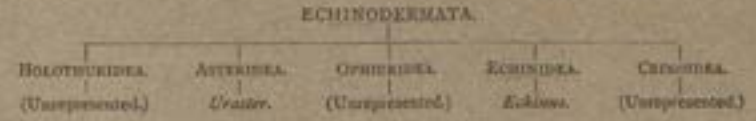
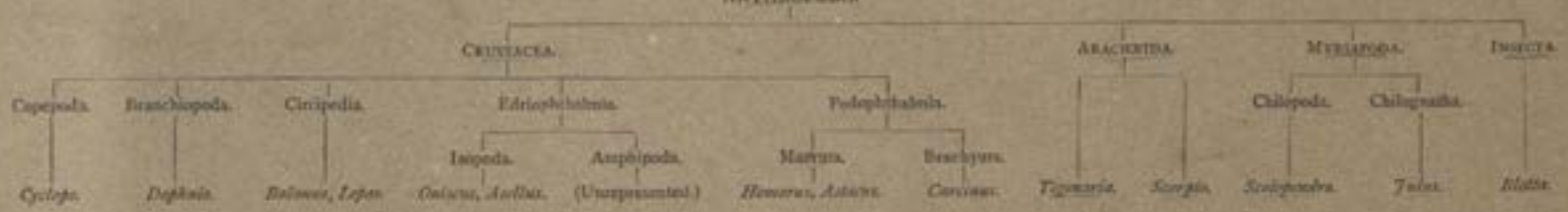
SUMMARY OF CLASSIFICATION.





TO ASSIST STUDENTS WE GIVE A LIST OF AVERAGE PRICES OF SPECIMENS FOR USE WITH "ZOOLOGICAL ATLAS."

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Skeletons of Birds	,,	8s. 6d.	
Skeleton of Tortoise		8s. 6d.	
,, Frog	from	4s.	
All kinds of Skulls	,,	2s. 6d.	
Disarticulated Lobster Mounted on Glass		30s.	
Skeleton of Mole on Stand		7s. 6d.	
,, Monkey, various	from 10s. to 30s.		
Dogs' Skulls	from	4s.	
Disarticulated Dog's Skeleton	,,	30s.	
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,, Squirrel		8s. 6d.	
,, Flying Fox		12s.	
,, Guinea-Pig		8s. 6d.	

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